THE EFFECTS OF INDIVIDUAL DIFFERENCES ON LEARNING FROM WRITTEN MATERIALS: THE CONTROL OF INSPECTION BEHAVIOR BY TEST-LIKE EVENTS

By

JOHN THURLOW WILSON

A DISSERTATION PRESENTED TO THE GRADUATE
COUNCIL OF THE UNIVERSITY OF FLORIDA IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA
1973

378
FO
1973
W749e
C.2

EDUCATION
LIBRARY

UNIVERSITY OF FLORIDA
3 1262 08552 7462

Dedicated to

the memory of my father,

NORMAN THURLOW WILSON

ACKNOWLEDGEMENTS

The author wishes to express his gratitude to his chairman, Dr. John J. Koran, Jr., for his guidance and assistance, and to the members of his committee, Dr. John F. Baxter, Dr. Wilson H. Guertin, Dr. Arthur J. Lewis, and Dr. Mary Budd Rowe for their constant encouragement and helpful suggestions.

Special thanks is also extended to Mr. Kenneth D. Loose for his assistance in computer programming and advice in the preparation of the data for analysis.

The author is especially indebted to Dr. Mary Lou Koran who gave generously of her time and effort as both a consultant and colleague. Her careful evaluation and suggestions concerning the many facets of researching and interpreting aptitude x treatment interactions helped make possible the successful conduct of this research.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS. iii

LIST OF TABLES. vii

LIST OF FIGURES ix

ABSTRACT. x

CHAPTER

I THE PROBLEM. 1

Definition of the Problem. 1

Background to the Problem. 1

Related Theory and Research. 5

Definition of Mathemagenic Activity. . 5
Research on the Control of Mathemagenic Activity. 10
Implications of Research on Mathemagenic Activity. 17

Definition of Variables for Aptitude x Treatment Interaction Studies. 18

Theory of ATI Research 18
Identification of Relevant Aptitudes . 23
Ability Measures 29

Independent and Dependent Variables. . . 31
Statement of Hypotheses. 32

II EXPERIMENTAL DESIGN. 34

The Design 34
Aptitude Measurements. 36
Treatment Procedures 38

Subjects 38
General Procedures 38

Treatment Materials. 41

Questions. 41

CHAPTER Page
Reliability of Measures. 43
Methods of Data Collecting 46

III RESULTS. 49

Independent and Dependent Measures . . . 49

Intercorrelations Among Measures . . . 50
Distribution of Scores Within Measures 54

Instructional Treatment Main Effects . . 54

Acquisition of Relevant and Incidental Information 58
Overall Post-test Performance. 64
Highlighting Effects 64

Aptitude x Treatment Interactions. . . . 75

Correlations of Ability Measures to Performance. 78
Evaluation for Aptitude x Treatment Interactions 84
Acquisition of Relevant and Incidental Information from Diagrams. 85
Acquisition of Relevant and Incidental Information from the Texts 88
Overall Post-test Performance. 97

IV DISCUSSION AND IMPLICATIONS. 100

Summary of Data: Hypotheses Tests . . . 100

Instructional Treatment Main Effects . 101
Aptitude x Treatment Interactions. . . 109

Individual Differences in Learning Relevant and Incidental Information. . 115
Mathemagenic Behavior: Some Implications For Future Research . . . 119

Variables Which May Influence Mathemagenic Activity. 120
Conclusion 124

APPENDICES. 126

APPENDIX
A DIRECTIONS TO STUDENTS 127
B READING PASSAGES 134
C INSERTED TEXT QUESTIONS. 156

Page

APPENDIX

D INSERTED DIAGRAM QUESTIONS 164
E POST-TEST. 172
F DATA SUMMARY FORM. 177
G DISTRIBUTIONS OF SCORES. 181

BIBLIOGRAPHY. 200

BIOGRAPHICAL SKETCH 204

LIST OF TABLES

TABLE		Page
1	ORGANIZATION OF TASK AND APTITUDE VARIABLES IN A MULTIPROCESS MODEL OF LEARNING	26
2	EXPERIMENTAL DESIGN.	35
3	APTITUDE MEASURES.	37
4	DISTRIBUTION OF SUBJECTS BY SEX, AGE, AND GRADE LEVEL.	39
5	ANALYSIS OF VARIANCE FOR TESTS OF INDEPENDENCE BETWEEN INCIDENTAL AND RELEVANT QUESTIONS	44
6	RELIABILITY AND DIFFICULTY OF POST-TEST QUESTIONS.	45
7	RELIABILITY OF MEASURES.	47
8	INDEPENDENT AND DEPENDENT MEASURES	51
9	INTERCORRELATIONS AMONG INDEPENDENT MEASURES	52
10	INTERCORRELATIONS AMONG DEPENDENT.	53
11	MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES.	55
12	MEANS AND STANDARD DEVIATIONS OF DEPENDENT VARIABLES.	56
13	MEANS FOR SUBSETS OF POST-TEST QUESTIONS .	59
14	ANALYSIS OF VARIANCE FOR SUBSETS OF POST-TEST QUESTIONS.	61
15	SCHEFFE TEST FOR DIFFERENCES BETWEEN MEANS OF INSERTED QUESTION TREATMENT CONDITION ON RELEVANT DIAGRAM QUESTIONS. .	62
16	SCHEFFE TEST FOR DIFFERENCES BETWEEN MEANS OF INSERTED QUESTION TREATMENT CONDITION ON RELEVANT TEXT QUESTIONS . . .	63

TABLE Page
17 MEANS OF POST-TEST MEASURES: TOTAL QUESTIONS. 65
18 ANALYSIS OF VARIANCE TOTAL POST-TEST PERFORMANCE. 66
19 PERCENTAGE OF DIAGRAM HIGHLIGHTED. 68
20 PERCENTAGE OF TEXT HIGHLIGHTED 69
21 ANALYSIS OF VARIANCE WITH REPEATED MEASURE FOR TREATMENTS WITH HIGHLIGHTING . 70
22 SUMMARY OF ANALYSIS OF VARIANCE OF HIGHLIGHTING FOR SIMPLE MAIN EFFECTS . . . 71
23 TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING DIAGRAM AT PASSAGE FOUR USING THE NEWMAN-KEULS PROCEDURE 72
24 TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING DIAGRAM AT PASSAGE SEVEN USING THE NEWMAN-KEULS PROCEDURE 73
25 TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING TEXT AT PASSAGE FOUR USING THE NEWMAN-KEULS PROCEDURE 74
26 INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR RELEVANT DIAGRAM QUESTIONS 79
27 INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR INCIDENTAL DIAGRAM QUESTIONS 80
28 INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR RELEVANT TEXT QUESTIONS. 81
29 INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR INCIDENTAL TEXT QUESTIONS. 82
30 INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR OVERALL POST-TEST PERFORMANCE. 83
31 SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF DIAGRAM QUESTIONS. 86
32 SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF TEXT QUESTIONS 90
33 SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF TOTAL POST-TEST QUESTIONS. . 98

LIST OF FIGURES

FIGURE Page

1 Percentage of Information Highlighted in Diagrams 76

2 Percentage of Information Highlighted in Text 77

3 Interaction of Treatment Time With Relevant Diagram Questions 87

4 Interaction of Inserted Questions With Relevant Diagram Questions 89

5 Interaction of Object-Number With Relevant Text Questions. 92

6 Interaction of Treatment Time With Relevant Questions 93

7 Interaction of Inserted Questions With Relevant Text Questions. 95

8 Interaction of Treatment Time With Incidental Text Questions. 96

9 Interaction of Treatment Time With Total Post-test Questions. 99

Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

THE EFFECTS OF INDIVIDUAL DIFFERENCES ON LEARNING FROM WRITTEN MATERIALS: THE CONTROL OF INSPECTION BEHAVIOR BY TEST-LIKE EVENTS

By

John Thurlow Wilson

June, 1973

Chairman: Dr. John J. Koran, Jr.
Major Department: Curriculum and Instruction

The purpose of this study was to examine the effects of verbal and perceptual aspects of learner aptitude, in relation to inspection behaviors performed while learning from written materials containing two modes of instructional content. Science instructional materials containing both text and diagrams were modified by inserting questions that asked for information either from the text or from the diagrams, or no questions. In addition, highlighting (Subjects marked "important information" with a yellow felt-tip marker) provided an additional treatment condition. It was expected that these variations in treatment conditions would influence the acquisition of both relevant and incidental information from diagrams and texts. Furthermore, it was anticipated that learner performance would exhibit differential response to the treatment conditions.

One hundred eighty five subjects were randomly assigned to one of six treatment groups in a 3 (types of inserted questions) by 2 (highlighting or no highlighting) factorial design. Subjects were given aptitude tests representing verbal and perceptual abilities in addition to treatment materials and post-test criterion measures. Post-test measures included performance on relevant diagram questions, incidental diagram questions, relevant text questions, incidental text questions. The percentage of information highlighted in the text and diagrams was also recorded.

Comparison of performances on relevant text or diagram questions by pairs of treatment conditions following an overall significant F ratio disclosed that inserted questions facilitated the acquisition of relevant information while exerting little influence upon the acquisition of incidental information. A repeated measures analysis using the amount of information highlighted as the repeated measure across written passages revealed that the change in the percent of information highlighted from the base rate for passage one significantly increased for diagrammatic information, but decreased significantly for texts. Relationships between aptitude to criterion scores were interpreted following significant F tests for heterogeneity of regression, indicating significant intersections of regression lines for alternative treatments. Results of these analysis disclosed positive relationships between the number of inserted questions answered and the performance on relevant post-test questions. Aptitude x treatment interactions were found between associative memory ability and performance on relevant text information, and also the time spent in the treatment and the performance on relevant and incidental post-test questions.

CHAPTER I

THE PROBLEM

Definition of the Problem

The purpose of this study was to examine the effects of verbal and perceptual aspects of learner aptitude, in relation to inspection behaviors performed while learning from written materials containing two modes of instructional content.

Background to the Problem

Written materials are convenient, easily managed, instructional stimuli. They are credited with the capability of directing learners toward predetermined outcomes by their potential to influence the activity of the learner. One way materials influence learning is to present selected information in a fashion believed to be compatible with acquisition. However, what specific variations facilitate acquisition and how they should be built into written materials in order to maximize learning activities remains to be empirically determined.

Several plausible approaches for arranging written instructional stimuli are currently being explored. One approach presents information in a progression from one level of prerequisite knowledge and skills to other more complex levels. When instructional sequences were, for instance, based upon hypothetical mathematical content structures, they were found to be effective for the acquisition of mathematics (Gagne and Paradise, 1961). This approach to learning depends on a cumulative learning sequence. Another approach segments the instructional stimuli into short periods with frequent repetition of information and practice activity as, for example, in programmed instruction. Here, repeated exposure is credited as a means of increasing the likelihood that the highly redundant information will be acquired.

Neither information hierarchies nor presentation-practice sequences can be considered as a generally suitable approach for all learners or content. Hierarchies, for example, are limited to the subject area of the hierarchy. In addition, hierarchial sequences assume that psychological activities associated with acquisition and performance on one level will be transferred and performed on subsequent levels. Presentation, repetition, and practice strategies attempt to control acquisition and performance by dividing practice and other aspects of the learning activity into relatively small discrete events. The capability to generalize this approach to a wide range of learners and conditions remains in question in view of research which supports the notion that not all instructional content can be subdivided into short segments with sub-events and trials as means to facilitate acquisition for all types of learners (Woodworth, 1938, pp. 19-20).

Many approaches to instruction have focused only upon the relationships between presented stimuli and observable performances, neglecting the many possible ways in which internal response processes work in relation to various stimuli and overt response variables. The fact that short segments may limit the range of these internal learner responses supports the objective of controlling the variance of acquisition among learners, but it also illuminates why more complex learning tasks, which are considered to be dependent upon a wider range of internal processes, are perhaps not suitable as content for highly segmented or hierarchial instruction. The possibility has received little consideration that the internal responses learners perform during instruction may be both educationally desirable and manageable. In addition, tactics for managing these activities may be generalizable across content tasks.

Ausubel (1968) has suggested that meaningful learning occurs when internal processes of the learner associates new information with subsuming concepts already in their cognitive structure. Written materials would promote effective processing by presenting content in "meaningful contexts." When suitable subsuming concepts do not already exist in the learner's cognitive structure, the concept can be presented in advance of the new information.

Ausubel calls concepts when presented in this manner, "advance organizers." Their effectiveness has been empirically demonstrated (Ausubel and Fitzgerald, 1962; Koran, J. J. and Koran, M. L., In Press).

Learning activity can also be directed by placing cues and prompts, such as questions, directions, diagrams, examples, within the written material. These direct the learner into the vicinity of the instructional objective (Hall, Lund, and Jackson, 1968), guide the selecting and processing of appropriate instructional objectives (Walker and Buckley, 1968), and shape the selection and processing of appropriate stimulus components (Bruning, 1968; Rothkopf, 1966; Frase, 1969). All these activities are classified as mathemagenic activities (Rothkopf, 1963). While some are considered to be gross motor in nature, such as manipulating objects, and therefore are observable and easy to measure, others include such covert inspection and processing activities as scanning, translating, formulating mental associations, discriminating, focusing, elaborating, and categorizing. The potential for instructional flexibility derived from the manipulation of mathemagenic activity underscores the need for their careful study.

It is the intent of this study to examine certain effects associated with inspection behavior, a subset of mathemagenic activity.

Related Theory and Research

Definition of Mathemagenic Activity

The concept of mathemagenic behavior focuses upon the observable and hypothetical activity learners perform when confronted with instructional stimuli. The term, mathemagenic was derived by Rothkopf from the two Greek roots mathema, which means "that which is learned" and gignesthai, which means "to be born." Therefore, mathemagenic behaviors are activities which give birth to learning (Rothkopf, 1965).

In describing how humans learn from written materials, a distinction can be made between the physical stimulus presented to the learner and the effective stimulus encoded by various internal processing activities performed by the learner (Rothkopf, 1970). This distinction simply implies that the physical stimulus is not in simple correspondence to the stimulus that has an effect upon psychological learning activity. The wide gap that probably exists between these stimuli may be the result of differential orientation of attention, structural variations of the sensory receptor surfaces, or even extent to which the learner transforms or elaborates the physical stimulus. However, since these effective stimuli become the basis for all subsequent psychological learning activity, their character determines what is learned (Rothkopf, 1970).

When learning from written materials, the learner must perform a prolonged and skilled activity, namely reading, if the desired instructional outcomes are to be achieved. Reading includes many mathemagenic activities both observable or hypothetical in nature. Observable activities may include orienting activities which direct learners into the vicinity of instructional objects and keep them there for suitable time periods; other activities serve to select and procure appropriate instructional objects once in the vicinity (Rothkopf, 1970). Hypothetical activities may also be performed and are, in general, of greater interest to research in view of their potential to facilitate learning.

One group of hypothetical mathemagenic behaviors is called translation and refers to activities where learners scan the written page and translate the alphabetic display into the sound of words or their subvocal surrogates. This process is considered preliminary to encoding selected bits of these alphabetic displays as elements of effective stimuli. Translation in itself is not enough, as verified when learners encounter difficult and boring written materials. Here translation may deteriorate into disorientation, an observable mathemagenic activity leading away from the instructional goal.

Another hypothetical behavior, often referred to as segmentation, includes learner activities that break the stimulus string into syntactic and other unit components

(Rothkopf, 1965). Segmentation generally attempts to account for the formulation of meaningful associative units within sentences as well as the more complex units associated between sentences.

A third hypothetical activity called processing, collectively includes a variety of mental activities learners perform with information such as reviewing, categorizing, elaborating, devising mnemonic associations, and other activities process information (Rothkopf, 1968). These activities all function to elaborate ways learners can incorporate prior learnings into otherwise unfamiliar written stimuli. They may potentially account for some of the vast variance between individual performances resulting from exposure to identical instructional stimuli.

While these categories of mathemagenic activities do not exhaust all possibilities, they have received attention because of their potential for research as well as their hypothesized involvement with acquisition. However, because these behaviors are mostly intervening variables, they require indirect measurement. Consequently when dealing with them, assumptions must be made by the research, concluding that these activities are persistent, topographical, exhibit rate characteristics, and modifiable by certain environmental events.

In order for mathemagenic hypotheses to become functional, ways to influence learning behaviors must be identified. Since these behaviors are basically sensitive to elements within the physical stimulus, variations within this stimulus can be incorporated which exert influence upon selected mathemagenic behavior. In this sense, the physical stimulus can be designed to include prompts and cues that shape the mathemagenic behavior. The success of their influence upon specific mathemagenic activity follows the notion that the behaviors can be shaped. However, implicit in this notion is that the learner responds in a manner guided by stimuli and reinforced by the success of his generating suitable responses.

Certain cuing or prompting techniques can be associated with each behavior identified above. Segmentation which involves selecting key bits of associated information, may be influenced by sentence order and relational wordage, including verb selection, tense, or proximity of key parts within the sentence (Anderson, 1970). Translation, which involves interpreting a stimulus string with suitable inflection, may be influenced by exposing learners to audio models of stimulus strings or underlining groups of words that receive special emphasis by inflection. Processing activities may be greatly influenced by directions, test-like events, and other cues which direct attention or review activity toward important classes of information within the reading activity.

Controlling mathemagenic activity means to exert an influence upon the formulation of the effective learning stimuli. Potentially these stimuli may reflect associations between new information elaborated by prior learnings. However, they may or may not be consistent with the instructional objective. Therefore, mathemagenic activities are considered to be effective when they facilitate acquisition and hence the attainment of instructional objectives.

In summary, a mathemagenic hypothesis recognizes a difference between the physical stimuli of instructional material and the effective stimuli learners construct for themselves using various covert and overt behaviors. Instructional materials which emphasize sequenced and segmented bits of information for practice and acquisition generally consider the physical and effective stimulus to be the same. Furthermore, the act of segmenting instruction into small bits may well encourage deterioration of several essential mathemagenic activities. Therefore, research into ways to shape and manipulate the mathemagenic activity potentially can lead to flexible use of instructional materials by reducing the need to task analyze and restructure all written materials. In addition, mathemagenic activities identify many variables potentially useful for describing individual differences between learners. After all, adequate description is an important prerequisite to effective prescription. Finally, mathemagenic approach concentrates on maintaining learner behaviors that produce learning. In so doing, it attempts to capitalize on the adaptive, error-correcting characteristics of human learning behavior (Rothkopf, 1968).

Research on the Control of Mathemagenic Activity

Interest in mathemagenic activity grew out of the use of questions within frames of programmed materials. Variations in question placement, frequency of questions, and predictability of response were found to influence performance in terms of acquisition and retention of information (Rothkopf, 1963). While the possibility exists that the variable use of questions may have a direct influence upon the acquisition of content *per se*, differences in acquisition indicate that questions may also influence mathemagenic activity relative to the processing of the instructional material. Perhaps variable use of prompts and cues, such as questions, could be selected and utilized within instructional materials according to their alleged potential to influence processing and thereby facilitate acquisition, rather than their more common utilization based upon their relationship to content structures. Consequently, studies of mathemagenic activity and factors that influence them may ultimately describe, from a generalizable perspective, ways to facilitate learning.

Hypothetical mathemagenic activities have received experimental attention and evidence is available that they are modifiable external events. Directions are one type of event which seem to influence these activities. Generally, research with directions have dealt with either directions of intent or manipulative directions for influencing search activity. Postman and Sanders (1946), for example, found that directions to learn specific classes from text material may influence learning, but their findings also demonstrated that facilitation was not necessarily in keeping with the intent of the directions. Three other studies (Bruning, 1968; Rothkopf, 1966; Tenenberg, 1969) indicated that vague oratory directions of intent affect learner's mathemagenic activity sufficiently to elevate post reading performance. Specific directions to find certain items of information in a test can also influence incidental learning, in addition to the direct acquisition of relevant items (Frase, 1969).

Evidence concerning the influence upon acquisition and retention through manipulation of the written passage itself indicates that variations in sentence order and repetition can alter inspection behavior associated with reading. When reading passages provided immediate repetition of sentences containing key attributive information, poor retention and acquisition resulted on post-tests even when the phrasing of the repeated sentence had been changed upon repetition (Rothkopf and Coke, 1966). Repeated exposure to the entire written passages resulted in increasing post-test performances with a maximum effect appearing after two such inspections (Rothkopf, 1968).

Furthermore, findings also suggested that the amount of learning relative to each reinspection of the written passage decreases, causing the learning curve to exhibit a negative acceleration. Finally, performances on most post-tests indicate that inserted questions generally have a larger measurable effect on the retention of information relevant to the questions than the incidental information (Frase, 1968b).

In studies concerned with the influence of hypothetical mathemagenic activity such as inspection behavior, it is important to demonstrate that instructional events do exert an influence upon the activity and accordingly a direct instructional effect upon acquisition. Direct instructional effects have been reported by many studies (Hershberger, 1964; Keislar, 1960; Rothkopf, 1963, 1965, 1966; Rothkopf and Coke, 1966) which generally contributed the effect to the repetition and practice learners perform when responding to content loaded questions. However, in order to demonstrate that the performance on a post-test is due to modified inspection behavior and not practice and repetition of content within questions, an experimental technique is required. An explanation of this technique will perhaps clarify some of the research findings associated with hypothetical mathemagenic activity.

Generally, studies using questions are incidental learning studies where performances are measured on a second set of questions similiar to the experimental questions. The experimental questions, often referred to as adjunct questions, are those placed at various locations within the instructional text material itself. However, the information necessary to answer the second set of questions, usually included on a post-test with the experimental questions, is identified as information incidental to the experimental questions. Hence, if a mathemagenic activity, such as inspection behavior, has been influenced positively, the subjects receiving the experimental questions inserted into the instructional material ought to acquire more incidental information than those subjects who do not receive the experimental questions. In this manner, any measured change between groups cannot be attributed to direct instructional effects of the question's content.

An important characteristic of questions, in addition to their potential to influence hypothetical activity related to learning, is their position in relation to the relevant content. Ample evidence is available to support the findings that a simple change in position can radically transform consequent behaviors associated with reading. Several studies (Bruning, 1968; Frase, 1967, 1968a; Rothkopf, 1966; Rothkopf and Bisbicos, 1967) show that experimental questions administered shortly after inspecting the text segment to which they are relevant produce significant gains in incidental learning. Questions when placed before relevant text material were found to provide significant depressing effects upon acquisition of incidental learning (Frase, 1968; Rothkopf, 1970). It was also found that when the frequency of questions placed before readings was increased, the acquisition of incidental and relevant information decreased. Questions inserted into text and placed after relevant segments of readings were found to promote an increase in acquisition of incidental and relevant information as their frequency increased (Frase, 1968a, 1968b). The general implication of these studies is that placing relevant questions after paragraphs may positively influence both a review and a general facilitative effect upon acquisition of information.

Most experimental uses of questions inserted into textual material have been designed to elicit responses best described as factual recall. While questions asked in school learning situations are certainly focused on more complex responses, taxonomies currently in popular use lack the precision needed in order to identify or specify these more complex responses (Frase, 1970). In view of this problem, types of questions generally were operationally defined by each researcher. Rothkopf and Bisbicos (1967), for example, asked different types of questions defined in terms of asking for definitions of common or technical terms. They found that groups exposed to inserted questions with technical terms had high recall of other technical terms. Frase (1968c) defined questions as either a comparative question, a specific question, or a general question. Questions were rated by indicating the amount of information within the written passage considered by the learner to be relevant to answering the question. Ratings indicated that the number of words perceived as necessary to answer questions increased in order of specific questions, comparative questions, and then general questions. In a follow up study (Frase, 1970), acquisition of relevant and incidental information was found to be a function of question type. Here, the least learning occurred with the general question, the most with specific questions. This was attributed to the learner modified behavior in accordance with the amount of information to be processed. In a recent study (Watts and Anderson, 1971), questions were defined in terms of response. Here, names of principles, examples from text, or names of psychologists associated with principles were response types. Their findings indicated that subjects given application questions perform significantly better than subjects with other questions.

Even though no central system was used for describing question type for classifying the nature of the written material, certain observations are possible to make in summary. Questions may stimulate learners to review the information encoded in their memory, considered as relevant to the topic of the question. If the content of the prose contains little information that seems relevant to the question, such as few names of psychologists or technical terms, then the amount of information for review is less than when prose contains a lot of information similar to the topic. This relationship between question type and the amount of similar information is also an important consideration when selecting questions which are to influence inspection behavior. If the prose contains little information of a nature similar to the type of response required, then inspection behaviors seem to become exclusive and few items of information are sought out. This notion is supported by research where similar responses were highly predictable. Here, subjects recalled significantly less incidental information than subjects whose responses were less predictable (Rothkopf, 1966; Watts and Anderson, 1971).

The learning that results from the insertion of questions into instructional materials has been empirically associated with several instructional variables including positioning, frequency, and type of questions. However, only a very beginning of a research attempt has been done to associate these variables with learner characteristics. Koran, M. L. and Koran, J. J. (1972) predicted that the pacing of questions would exhibit varying facilitative effects, depending upon specific learner differences in learning ability. Their findings indicated that measures of learner associative memory abilities were positively related to performance when subjects received inserted questions, but unrelated when they received no inserted questions.

However, scores on vocabulary measures were positively related to performance when no questions or infrequent questions were inserted into the written material. These findings support the notion that instructional variables, such as the pacing of questions, can enable learners to capitalize on various learning characteristics and aptitudes. The Koran, M. L. and Koran, J. J. (1972) study represents an initial effort to match or select instructional treatment variations to selected learner characteristics. Additional research and replication is necessary before decision rules can be formulated to predict the assignment of learners to alternative instructional treatments designed to facilitate their attainment of identical outcomes.

Implications of Research on Mathemagenic Activity

Incidental learning effects in the aforementioned context have been attributed to the control which the questions inserted into text material exercise over mathemagenic activities. This assumes that behaviors subsequent to the inserted questions are modified Often referred to as "forward shaping" (Watts and Anderson, 1971), questions are assumed to act as cues in that they indicate classes of information that should be learned. When this class of information enables the subject to answer the question, he is reinforced just for being able to answer the question and therefore the likelihood is that he will again look for this same kind of information.

Questions, however, may also serve to influence the learner activity in another way. When faced with the problem of answering the question, the learner may mentally review the information he considers to be relevant to the cues found within the question. This mental review acts as additional practice, a variable of instruction well known for its direct effects upon increasing acquisition of information. This mental review has been referred to by Watts and Anderson (1971) as "backward review."

"Forward shaping" and "backward review" remain a prominent controversy without empirical evidence. In view of the plea by Koran, M. L. and Koran, J. J. (1972) to relate instructional variables to learner characteristics, such evidence should be collected in a fashion as to enable an association of performance variations with differences between individual learners.

Definition of Variables for Aptitude x Treatment Interaction Studies

Theory of ATI Research

A continuous problem related to the development of effective instruction is that of determining the most effective methods for training large numbers of individuals possessing dissimilar patterns of abilities. A common strategy has been to seek "the one best method of instruction." However, learners differ, and the search for the one generally superior method should be supplemented by a search for multiple ways in which instruction can be varied so as to fit the characteristics of learners (Cronbach and Snow, 1969).

As Cronbach (1957) has argued:

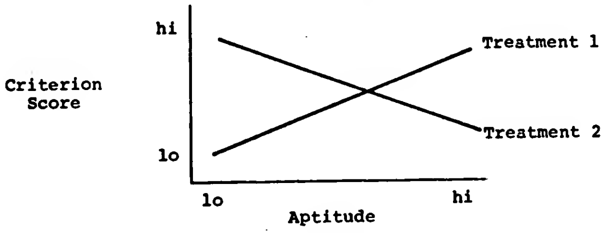
> Treatments are characterized by many dimensions; so are persons. The two sets of dimensions together determine a payoff surface . . . Ultimately we should design treatments not to fit the average person, but to fit groups of students with particular aptitude patterns which correspond to modifiable aspects of the treatment (pp. 680, 681).

An implication of this statement is that we should not ignore interactions between learners' aptitudes and various instructional treatments, but adapt instructional treatments to learners' aptitudes. In 1965, Cronbach (1965) developed a theoretical framework to deal with the nature of different aptitudes and differing instructional treatments. He called these studies aptitude treatment interaction studies, or more commonly called ATI studies.

The concept of ATI is neither new nor limited to educational settings. In Darwin's view, natural selection operates to favor whatever species or subspecies that has characteristics suited to a particular set of environmental conditions. If the environmental conditions change a different kind of organism is favored. The concept of a single rank ordering applied either to organisms or environments ignores the fundamental principle that it is the interaction between the characteristics of the organism and the demands of the environment that determines survival or elimination. Similarly, the current search for ATI is based on the premise that there is no one best educational environment suited to some general, average individual, but that different individuals thrive in different educational environments suited to their own characteristics and needs (Koran, M. L., 1973).

Practically speaking, an interaction between aptitude and treatment is present when one instructional treatment is significantly better for one type of learner, while an alternative treatment is significantly better for a different type of learner. Specifically, in order for instructional treatments to exhibit ATI, there must be different instructional methods, the instructional methods must teach to the same objective or criterion, and there must exist one or more aptitude measures for which regression of criterion scores on the aptitudes are generally non-parallel.

There are essentially two different interactions which may result; they may be either ordinal or disordinal in nature (Cronbach and Snow, 1969). A disordinal interaction is one in which the regression slopes intersect within the range of the aptitudes being considered, as shown in the figure below.



Disordinal Interaction

Such findings imply, in general, that differential assignment of subjects on opposite sides of the intersection to alternative treatments is an appropriate means for maximizing learning outcomes (Koran, M. L., 1973). An ordinal interaction is present when the regression functions have different slopes, but one is superior to the other through the range of aptitudes being considered.

The general objective of ATI research is to match instructional methods or materials to selected learner characteristics. Therefore, unless one treatment is clearly best for all, treatments should be differentiated in such a way as to maximize their interactions with aptitude variables. A moderate number of studies in which aptitude-treatment interactions have been deliberately sought (Cronbach and Snow, 1969; Berliner and Cahen, 1973) provides preliminary evidence to suggest that subjects may learn more easily from one method than another. Furthermore, this best method differs from subject to subject and that such a difference between treatments is related to learner characteristics.

For the purpose of ATI research, aptitude has been defined as any characteristic of the individual which functions selectively with respect to learning; that is, which facilitates or interferes with his learning from some designated instructional method (Cronbach and Snow, 1969). This definition allows such variables as task-specific knowledge and skills, cognitive styles, personality characteristics and heuristic strategies to be considered as well as the more traditional cognitive ability variables.

A major problem in the study of ATI is the inordinately large number of learner characteristics which might be considered in adapting instruction to individual differences. Furthermore, few of these differences have been shown to be correlated with specific learning outcomes under specific instructional methods in the particular population specified. Even the treatments themselves are limited in description which lack precise identification of task or treatment variables.

It is not uncommon in ATI research to find two treatments; one of which relies more heavily on general ability than the other. Some research report instances in which a treatment will help those of low ability while actually hindering high ability students (Salamon and Suppees, In Press; Koran, Snow and McDonald, 1971). However, there has been little real progress to date in identifying heuristics for developing treatments that actually capitalize on aptitudes other than general ability.

Generally, research is needed to identify the kinds of abilities and processes required by various tasks. Then, the conditions assessed as necessary for learning the task could either be adapted to identified individual differences or the individual might be taught how to engage more effectively in these processes (Glaser, 1972).

Identification of Relevant Aptitudes

The acquisition and subsequent retention of information from instructional sequences can be analyzed as a function of numerous variables including learner predispositions and variations within the treatment materials. While these variables can be factor analyzed in order to relate performance to a number of reference tests, such as analysis must be guided by theories of human learning and performance in order to facilitate the interpretation of results. Melton's (1967) multiprocess model of learning is considered to be a suitable framework for investigating instructional differences and mediational requirements between specific instructional variables.

$$\begin{tikzcd}
 & & r_m(s_m) \arrow[dr] & \\
s_1 \arrow[r] & r_1(s_1) \arrow[ur] \arrow[rr] & & R_aR_bR_c
\end{tikzcd}$$

Multiprocess Model of Learning

This model presents three major components that help interpret certain instructional phenomena. The first of these is a stimulus differentiation component $[s_1 \longrightarrow r_1]$ in which the subject receives the physical stimulus $[s_1]$ and selects and encodes certain stimuli as stimulus cues $[r_1(s_1)]$. The potential stimulus is considered to be the entire stimulus situation of the learning environment. The encoded stimulus becomes the effective or functional stimulus in S-R association, and reflects learning set, identification and categorization factors, as well as the physical stimulus. Instructional materials attempt to indicate the relevant aspect of the physical stimulus through the selection of reading passages, questions, diagrams, summaries, and other instructional components. From this, the student selects particular aspects which become the stimulus cues. Directions, instructions, elicitations, or models that direct this selection are called prompts. The encoded response $[r_1(s_1)]$ becomes the effective or functional stimulus for subsequent psychological learning activities.

The response integration component $[R_aR_bR_c]$ is the output response and includes certain learning behaviors such as naming, classifying, or chaining as well as the specific content presented in the instructional materials. Such behavior may be a previously learned unit $[R_a]$, or a new combination of units $[R_aR_bR_c]$, or even a chain of responses from one stimulus situation $[R_a+R_b+R_c]$.

The "hookup" is the connection $[r_1(s_1) \longrightarrow R_aR_bR_c]$ between the functional stimulus $[r_1(s_1)]$, and the acquired response $[R_aR_bR_c]$. The component $[r_m(s_m)]$ presents an alternative mediational route for the connection of internal representation of the physical stimulus and the acquired response. The mediational route is especially important in examining ways learners can use prior learning with new but recognizably similar stimuli. The associational and mediational routes correspond to the internal processes of the task being analyzed.

Differences and similarities in task and aptitude variables involved in learning from different modes of information within instructional material may be represented in terms of this paradigm. This representation is presented in Table 1. The organization of ability measures within the modes has been somewhat arbitrary. Measures identified are sufficiently diverse to suggest that there is reason to consider alternative placement. Some measures may also be characterized by overlapping several placements. However, it should be emphasized that this model has been used as a heuristic device in attempting to select and organize task and ability variables. It is not intended that the present organization be accepted as definitive. Further research will be required to clarify the use of this model.

Textual information presents specifics in verbal form and assigns them meaning by direct association within the

TABLE 1

ORGANIZATION OF TASK AND APTITUDE VARIABLES
IN A MULTIPROCESS MODEL OF LEARNING

	$s_1 \longrightarrow r_1(s_1)$ Stimulus Differentiation	$\nearrow r_m(s_M) \searrow$ Association, Mediation	$\longrightarrow R_aR_bR_c$ Response Integration
Textual Information Mode	Read passages at own pace.	Review specifics in memory.	Retain written verbal associations.
	Select solely verbal specifics for coding.	Generate associative context.	Generate verbal recall responses to test-like events.
	Code in verbal representation.		
Diagrammatic Information Mode	Inspect and read diagrams.	Review specifics in memory.	Retain verbal and figural specifics.
	Select verbal and figural specifics for coding.	Review associative context of diagram and specifics.	Generate verbal recall responses to test-like events.
		Generate verbal linkage for figural specifics.	
Aptitude Variables	Flexibility of Closure.	Verbal Association.	Associative Memory.
	Perceptual Speed.	Verbal Comprehension.	Verbal Association.
	Verbal Comprehension.		Short Term Memory.

sentence as well as by association between specifics of different sentences. Subjects reading textual information must first differentiate relevant specifics and their associations and then code these in memory. Consequently, textual modes of information present stimulus differentiation tasks that would require abilities in comprehension of verbal information and short term memory.

The many possibilities for meaningful associations within textual information increases the mediational requirements. Subjects learning from textual information would generate an associate structure for processing the various stimulus specifics and their associations. This structure generation would require many abilities including verbal association.

Diagramatic information presents specifics in a symbolic form which attains meaning from both the symbolic representation, any labels or verbal identifications provided, and its relationship to the other parts in the diagram. Subjects learning from diagrams with many parts and various modes of information would need abilities in perception in order to differentiate stimulus components. Quickly inspecting and processing multiple kinds of information, selectively attending to relevant details over incidental ones is a task similar to what is commonly called flexibility of closure (Thurstone, 1944).

Diagrams can be considered to present specifics within an organizational schema of associations between specifics through their visual proximity and sequence. While stimulus differentiation may assess associations between the symbols and the labels, mediational requirements include generating some associational structure for proximity and sequence. This task receives support from the diagram itself which supplies an organizational structure. Consequently, the mediational requirements for learning from diagramatic information could require subjects to recall specifics and associate them with the diagramatic structures provided within the diagrams.

Finally, the response integration for both modes of information require subjects to recall or review specifics and associations relevant to response conditions. This task would require abilities in verbal comprehension and verbal association.

Processes that subjects perform during a learning task are assumed to be influenced by external conditions. These conditions may include instructional tactics such as inserting questions into textual material or instructing subjects to mark important information. If these conditions were to influence processing activity, they probably would have their greatest effect on tasks where the tactics either support or compensate for the aptitude required by the tasks. Hence, marking important information would have its greatest effect on tasks where selective perception to detail would be essential, such as when learning from diagramatic information. Probably, subjects with low perception abilities would benefit most from this tactic. Questions, on the other hand, which identify classes of information and their possible relational structures, would have their greatest effect on tasks where classes of information and their associations are not readily apparent, such as in textual information. Subjects with high verbal skills would probably benefit the least from frequent questioning.

Ability Measures

The selection of ability measures for use in this study was made from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, and Price, 1963). The abilities assessed by the selected measures were believed to be those which clearly contribute to learning from the two modes of information and are consistent with the analysis of textual and diagrammatic information modes previously discussed.

The Kit of Reference Tests for Cognitive Factors consists of a group of tests representing frequently obtained factors in the cognitive ability area. Since these tests are not standardized batteries of exams, the manual does not provide reliability, validity, norms, or other information usually included with a test manual. However, this exclusion is consistent with the general intention that the tests were designed for cognitive factor research. Users must calculate reliability of the instruments employed using suitable analyses.

A brief description of the ability tests and the factors they represent follows.

Hidden Patterns (Cf-2) is a test of the ability to keep one or more definite configurations in mind so as to make identification in spite of perceptual distraction. The subject is required to search a perceptual field containing irrelevant or distracting materials in order to find one given configuration.

Vocabulary (V-2) is a test of the ability to understand the English language. Individual differences are perhaps most clearly seen in the size of comprehensive vocabularies, but they also exist with respect to tests demanding knowledge and understanding of grammatical patterns, sentences, idiomatic phrases, and other aspects of the English language. However, vocabulary tests are more desirable than tests of grammar and other language features because, on the whole, their loadings on Factor V are high and less likely to have loadings on other factors.

Object-Number (Ma-2) is a test of the ability to remember bits of unrelated material. This factor represents the ability to form and remember new associations quickly.

Auditory Letter Span (Ms-3) is a test of the ability to recall perfectly for immediate reproduction a series of items after only one presentation of the series.

Number Comparison (P-2) is a test measuring the speed in finding figures, making comparisons, and charting out other very simple tasks involving visual perceptual speed. It is considered to be the centroid of several sub-factors such as speed of symbol discrimination, speed of making comparisons, forming discrimination, and speed of classification. However, they also serve a useful purpose when considered as the unitary concept of perceptual speed.

Independent and Dependent Variables

The purpose of this study was to investigate the effects of learner aptitudes, in relation to inspection behaviors performed when learning from written materials. As an intervening variable, inspection behavior is a hypothetical construct for which evidence must be inferred. However, it is also considered to be sensitive to inserted adjunct questions located within the relevant written material. Whether or not inspection behavior is influenced by the adjunct questions can be inferred by comparing performances on a post-test performance between groups that received the adjunct questions and groups that did not. Here, differences in the information acquired that is incidental to the adjunct questions is considered to be an indirect measure of inspection behavior.

The dependent variables in this study include the between-group differences in performance of incidental information. Adjunct questions, when they appear on the post-test, are also dependent measures of the direct instructional effects of the inserted adjunct questions. Even though the process of subjects highlighting information within the written material can be identified as an independent variable, the resulting patterns of information contribute another dependent measure for inferring the nature of inspection activity of the subjects.

When aptitudes are included in addition to the instructional variables built into the instructional treatment, then differential performance of the treatment group can be compared by regressing the aptitude measure on the post-test performance. In this manner, a relationship can be established between learner characteristics and instructional variables that influence inspection behavior and acquisition. Hence, student behavior, mathemagenic activity, and the constructs which influence it are independent variables. Aptitude measures are also independent measures and the dependent variables again become the post-test measure of both relevant and incidental information acquired.

Statement of Hypotheses

Based upon the previously reviewed research and theory, the following hypotheses were tested.

1. Subjects receiving treatments with adjunct questions inserted into the written passage

will exhibit significantly greater acquisition of relevant information than the control group.

2. Subjects receiving treatments with adjunct questions based upon diagrammatic information inserted into the written material will exhibit significantly greater acquisition of incidental information from diagrams than groups that did not receive diagrammatic adjunct questions.
3. Subjects receiving treatments with adjunct questions based upon textual information inserted into the written passage will exhibit significantly greater acquisition of incidental information from text than groups that did not receive textual adjunct questions.
4. There will be a significant influence on performance for subjects who receive treatments in which they highlight information in the written materials.
5. There will be a differential relationship between criterion performances and aptitudes of subjects, relative to the treatment received.

CHAPTER II

EXPERIMENTAL DESIGN

The Design

A post-test only, control group design as described in Table 2, was executed with four experimental and two control groups. While this design does not assess entering behavior, it does permit an adequate evaluation of the relative effects that an independent variable, question type, has upon a dependent variable, the acquisition of information from different modes of instructional material (Kirlinger, 1964, p. 303). This design also facilitates asking the question of whether or not questions serve to stimulate review or shape the inspection behavior of the subsequent passages. The design, therefore, provides a means for contrasting acquisition after reading and answering inserted questions, as well as the effect these questions had upon subjects' inspection activity within each reading passage. Hence, the written materials were selected to include both texts and diagrams as sources of information. Questions were then written that required information from either one or the other source. Highlighting, or marking with a yellow felt-tip marker, was used to monitor the inspection behavior of the subject.

TABLE 2

EXPERIMENTAL DESIGN

Treatment		
Highlighting	Inserted Questions	Post-Test
X	Diagram questions	0_1
X	Text questions	0_2
	Diagram questions	0_3
	Text questions	0_4
X	No questions	0_5
	No questions	0_6

Aptitude Measurements

Subjects were tested after their participation in the experimental procedures. As shown in Table 3, test time was limited to a single forty-five minute period during the school day due to the constraints encountered in the cooperating schools. The tests were assembled into a single booklet and administered using an audio-recording of all the necessary instructions, practice exercises, times, and additional auditory test materials as required by certain tests.

While all subjects could not be tested at one time, groups were all tested in a like manner. Since members of each class had previously been randomly assigned to one of the six treatment groups, any regressive effects caused by testing during classes of a regular school day were also randomly distributed to all treatments.

Tests were hand scored by a trained rater, working under the direction of the experimenter. Objective test scoring keys were used on all tests. The scores reported were always the number of items right except on those tests where choices were dichotomous; here, scores were calculated by subtracting wrong choices from correct choices in order to correct for guessing.

TABLE 3

APTITUDE MEASURES

Test	Time	Number of Parts Given
Kit of Reference Tests for Cognitive Factors		
Hidden Patterns (Cf-2)	2 minutes	1
Vocabulary (V-2)	8 minutes	2
Object-number (Ma-2)	6 minutes	1
Auditory Letter Span (Ms-3)	3 minutes	1
Number Comparison (P-2)	1 1/2 minutes	1
Actual Test Time	20 1/2 minutes	
Administration, practice sets	20 minutes	
Total Test Time	40 1/2 minutes	

Treatment Procedures

Subjects

Ninth through twelfth grade students enrolled in high-school chemistry and physics were identified as suitable subjects on the basis of the complexity and scientific nature of the content presented in the written materials. A total of 185 subjects were selected from two local high schools. Relevant characteristics of these treatment samples appear in Table 4.

General Procedures

Subjects participated in the experiment during the period that they normally would have had a chemistry or a physics class. Since these classes are seldom found to have students who are alike in ability or interest, subjects within each class were randomly assigned to one of the six treatments.

After subjects were given a brief introduction to the experiment, they were provided with the appropriate booklet containing both the treatment materials and the post-test. Highlighters (yellow felt-tip pens) were provided for subjects assigned to treatment which required them.

Although a common practice is to read all directions aloud to all subjects in order to encourage closer compliance, this was not feasible in this experiment

TABLE 4

DISTRIBUTION OF SUBJECTS BY SEX, AGE, AND GRADE LEVEL

Treatment Group	Number	Sex		Grade Level		Age	
		Male	Female	Mean	S.D.	Mean	S.D.
1. Highlighting/ Diagram Questions	29	14	15	10.69	.929	15.72	1.162
2. Highlighting/ Text Questions	30	15	15	10.57	.817	15.63	.890
3. No Highlighting/ Diagram Questions	32	14	18	10.50	.916	15.63	.942
4. No Highlighting/ Text Questions	29	18	11	10.76	.958	15.59	.780
5. Highlighting/ No Questions	32	20	12	10.44	.801	15.53	.915
6. No Highlighting/ No Questions	33	24	9	10.36	.822	15.54	.938

since subjects during administration had different treatments and hence different directions. Therefore, they were instructed to read the directions carefully and independently.

Four sets of directions were written. Subjects that were assigned to treatments with inserted questions were given a page of "Directions for Answering Study Items." (All direction pages are included in Appendix A.) Study item directions informed subjects that self-test questions would be given at the end of each reading passage and that they should attempt to recall the information necessary and attempt to answer it, even if their answer is only a guess. Only subjects that were in treatments with highlighting were given a page of "Directions for Highlighting," which demonstrated how to highlight both text and diagram portions of the reading passage. Subjects were directed to highlight all the information they considered important and worth remembering in order to answer the post-test items. All subjects were given a page of "General Directions" which encouraged them to read and study both the diagrams and the written information; these directions also informed them that a set of test items would be given after all reading passages asking for specific information from each passage. All subjects were given a page of "Directions for Answering Test Items" at the conclusion of all treatment materials. The subjects were encouraged to answer all questions, even if some answers were guesses.

Treatment Materials

Written Passages

Seven reading passages were selected from Dr. Posin's Giants (Posin, 1961). (These passages are included in Appendix B.) This number was found to be the maximum number that most students could complete with enough time remaining for the post-test within the constraints of a forty-five minute class period. Each passage is about 225 words long and is presented on two pages with one diagram on each page. Diagrams were modified to include labels. The number of sentences in the text varied from eight to twenty, while the number of specifics included in the diagram varied from ten to twenty. The content presented in the diagram and text contained redundant as well as independent specifics. The latter information became the content for questions.

Questions

Questions varied in terms of the source of the information needed for a response. One type of question required information from the text while a second type required information from diagrams. Question complexity was controlled in that all were limited to the recall of specific information, such as the names of symbols, objects, definitions, events, properties, or processes.

Four questions were written for each passage; two of these asked for text information and two for diagram information. Each of these questions were then assigned to one of four groups: Relevant Text Questions, Incidental Text Questions, Relevant Diagram Questions, Incidental Diagram Questions. As a result, the composition of each set of questions contained one question from each passage. Treatments with inserted questions received either the Relevant Text Questions or Relevant Diagram Questions. (These questions are included in Appendix C and D respectively.) All questions were combined and randomly ordered to make up the post-test. (The post-test is included in Appendix E.)

Questions were tested in order to determine their relative independence. Questions are considered to be independent when knowing the response to one question does not cue the subject to a correct response for the others. Independence must be established for questions in this study in order to assume that between-group performance differences on Incidental questions is due to differences in inspection behavior. Subjects (N=60) were randomly assigned to three groups. One group was given the fourteen pairs of questions with Relevant questions answered, the second group was given the same questions with Incidental questions answered, and the third group was given the same questions with neither set of questions answered. The means and standard deviations for all groups, in addition to the results from ANOV tests for significant differences are reported in Table 5. The insignificance of the F test was accepted as sufficient evidence that knowing the responses to one set of questions does not contribute to answering the other set of questions. Therefore the two sets of question pairs were considered to be independent.

Reliability of Measures

Twenty-eight questions were written comprising the criterion measure. A point bi-serial correlational technique was selected to evaluate their reliability. This technique is considered to be a suitable means to estimate a question's potential to discriminate between subjects who score in the top half and those in the bottom half of the group being tested. A point bi-serial correlation of 0.222 ($p < .01$) was considered minimum for acceptable reliability for individual criterion items. Bi-serial correlations for the questions are reported in Table 6. Reliabilities of all questions were found to be acceptable.

The difficulties for the twenty-eight questions were calculated and are also reported in Table 6. Difficulty, here, is defined to be the percent of the subjects failing to answer the question correctly. The higher the percent, the more difficult the item. The mean difficulty was 0.669, while the range of difficulties varied from 0.174 to 0.940. The research on the effects of questioning and

TABLE 5

ANALYSIS OF VARIANCE FOR TESTS OF INDEPENDENCE BETWEEN INCIDENTAL AND RELEVANT QUESTIONS

		Incidental Questions				Relevant Questions			
Source of Variation	df	Mean	S.D.	M.S.	F	Mean	S.D.	M.S.	F
Between Groups	1			.025	.05			.225	.34
Answers Given		.75	.70			.90	.83		
No Answers Given		.70	.64			.83	.77		
Within Groups	38			.472				.672	

TABLE 6

RELIABILITY AND DIFFICULTY OF POST-TEST QUESTIONS

Question	Difficulty	Reliability*
1	.826	.476
2	.418	.384
3	.745	.341
4	.940	.333
5	.766	.221
6	.462	.442
7	.712	.419
8	.592	.457
9	.652	.521
10	.554	.365
11	.174	.420
12	.440	.355
13	.848	.321
14	.641	.497
15	.929	.297
16	.739	.358
17	.908	.387
18	.484	.522
19	.832	.363
20	.533	.407
21	.848	.321
22	.511	.446
23	.484	.511
24	.886	.384
25	.641	.434
26	.880	.298
27	.815	.263
28	.473	.521

*(p .01) = .222
df = 183

mathemagenic activity does not report any data concerning the difficulty of the question, hence all questions were accepted as suitable, even though they were difficult.

As Draper and Smith (1966, p. 29) point out, measures with excessive error variance and hence low reliability contribute to insignificance of regression where significance could exist. Hence, reliabilities using the Cronbach alpha (1970) were calculated not only for the post-test and ability measures, but also for all part scores as well. These reliabilities are reported in Table 7. Generally, the reliabilities for the post-test and the ability measures were acceptable. The reliabilities of the part scores were accepted even though they were somewhat lower. This low reliability was attributed to the relatively few items that were used to determine these part scores.

Methods of Data Collecting

Subjects recorded their answers in a booklet clearly labeled with vital personal information. One set of booklets was constructed to contain the necessary treatment materials and post-test while a second set contained the aptitude measures. The booklets were then scored and data transferred to a "Data Summary Form" (Included in Appendix F). From these forms, necessary data were transferred to IBM cards. Duplicate sets of data cards were made in order to facilitate multiple analysis and data security. Key punching,

TABLE 7

RELIABILITY OF MEASURES

Measure	Number of Items	Reliability
Criterion Measures		
Post-test	28	.78
Relevant Text Questions	7	.48
Incidental Text Questions	7	.51
Relevant Diagram Questions	7	.47
Incidental Diagram Questions	7	.46
Ability Measures		
Hidden Patterns (Cf-2)	200	.91
Vocabulary (V-2)	36	.71
Object-Number (Ma-2)	15	.73
Auditory Letter Span (Ms-3)	15	.56
Number Comparison (P-2)	48	.85

scoring, and analysis were performed by trained technicians under the direction of the experimenter.

CHAPTER III

RESULTS

The primary objectives of this study were

1. to assess the relative effects of different instructional variables upon inspection behavior, and
2. to explore the effects of individual differences on learning from different modes of instructional content.

This chapter will describe the statistical tests of the hypotheses and the results achieved. The presentation of results will first treat the instructional treatment main effects and then the aptitude x treatment interactions. Most analyses were computed using the University of Florida Statistical Programs Library.

Independent and Dependent Measures

Inspection behavior is an intervening variable credited with influencing the acquisition of information from instructional material, such as prose. However, the study of inspection behavior is limited to the analysis of indirect evidence. This evidence can be identified as either an independent or dependent measure. Independent measures include those which potentially may predict a learner's performance relative to a specified instructional treatment. As presented in Table 8, this study included independent measures generally described as aptitudes, time, and inserted question scores. Dependent measures included evidence describing performance variables which were influenced in some way by experimental manipulation. In this study, dependent measures (Table 8) included post-test measures for the acquisition of relevant and incidental information from textual and diagrammatic portions of the written passages, and percentages of diagrammatic or textual information highlighted within written passages.

Intercorrelations Among Measures

Intercorrelations of both independent and dependent measures were computed for the total sample. For the most part, the intercorrelations among the independent measures (Table 9) display low correlations with one another, particularly among the factor tests. This is in accordance with the expectations regarding correlations among factor tests that purport to measure different things, hence tend to be independent. Intercorrelations among the dependent measures (Table 10), revealed some higher correlations among post-test measures, in particular, between the sets of diagram question scores. In general, other dependent

TABLE 8

INDEPENDENT AND DEPENDENT MEASURES

Independent Measures	Dependent Measures
Vocabulary, Part I	Post-test Measures
Vocabulary, Part II	Relevant Diagram Questions
Vocabulary, Total	Incidental Diagram Questions
Number Comparison, Part I	Relevant Text Questions
Hidden Patterns, Part I	Incidental Text Questions
Auditory Letter Span	Over-all Post-test Performance
Object-Number, Part I	Highlighting Measures
Treatment Time	Percent of information highlighted in diagrams
Test Time	Percent of information highlighted in text
Inserted Questions	

TABLE 9

INTERCORRELATIONS AMONG INDEPENDENT MEASURES

Performance Measures	2	3	4	5	6	7	8	9	10	n
1. Vocabulary, Part I	.72	.92	.30	.26	.31	.05	-.20	-.09	.16	185
2. Vocabulary, Part II		.93	.27	.28	.41	.06	-.21	-.19	.10	185
3. Vocabulary, Total			.29	.28	.39	.06	-.21	-.14	.14	185
4. Number Comparison, Part I				.33	.27	.02	-.30	.01	.05	185
5. Hidden Patterns, Part I					.21	-.01	-.16	.06	.01	185
6. Auditory Letter Span						.20	-.19	.00	.09	185
7. Object-Number							-.03	.13	.05	185
8. Treatment Time								-.14	.26	185
9. Test Time									.01	185
10. Inserted Questions										120

TABLE 10

INTERCORRELATIONS AMONG DEPENDENT

Performance Measures	2	3	4	5	6	7	n
Post-test Measures							
1. Relevant Diagram Questions	.51	.29	.42	.73	.29	.06	185
2. Incidental Diagram Questions		.51	.48	.82	.14	.09	185
3. Relevant Text Questions			.48	.73	.04	.02	185
4. Incidental Text Questions				.78	-.07	-.01	185
5. Over-all Post-test Performance					.13	.05	185
Highlighting Measures							
6. Percent of information highlighted in diagrams						.30	91
7. Percent of information highlighted in text							91

measures of time and highlighting displayed lower correlations with one another as well as with other dependent measures.

Distribution of Scores Within Measures

Means, standard deviations, and distributions of both independent and dependent measures were computed for the total sample. The means and standard deviations for the independent measures are presented in Table 11, and for the dependent measures, Table 12. The distributions of these scores by treatment group are presented in Appendix G. An inspection of these means, standard deviations, and distributions indicated that most data did not appear to deviate from a normal distribution to warrant further testing. However, scores on post-test measures displayed some grouping generally credited to the limited range of the scores and to the high difficulty of the items.

Instructional Treatment Main Effects

The following hypotheses were of major concern relative to instructional treatment main effects:

1. Subjects receiving treatments with adjunct questions inserted into the written passage will exhibit significantly greater acquisition of relevant information than the control group.

TABLE 11

MEANS AND STANDARD DEVIATIONS OF INDEPENDENT VARIABLES

Performance Measure	n	Mean	S.D.
Vocabulary, Part I	185	8.59	3.35
Vocabulary, Part II	185	8.89	3.37
Vocabulary, Total	185	17.43	6.25
Number Comparison, Part I	185	10.62	3.83
Hidden Patterns, Part I	185	28.17	9.92
Auditory Letter Span	185	5.69	1.92
Object-Number	185	5.80	3.66
Treatment Time	185	21.30	7.22
Test Time	185	10.58	4.82
Inserted Questions	120	2.98	1.48

TABLE 12

MEANS AND STANDARD DEVIATIONS OF DEPENDENT VARIABLES

Performance Measure	n	Mean	S.D.
Post-test Measures			
Relevant Diagram Questions	185	2.12	1.53
Incidental Diagram Questions	185	3.11	1.64
Relevant Text Questions	185	1.73	1.46
Incidental Text Questions	185	2.31	1.60
Over-all Post-test Performance	185	9.30	4.80
Highlighting Measures			
Percent of information highlighted in diagrams	91	12.19	17.22
Percent of information highlighted in text	91	39.35	19.95

2. Subjects receiving treatments with adjunct questions based upon diagrammatic information inserted into the written material will exhibit significantly greater acquisition of incidental information from diagrams than groups that did not receive adjunct questions.
3. Subjecta receiving treatments with adjunct questions based upon textual information inserted into the written passage will exhibit significantly greater acquisition of incidental information from text than groups that did not receive textual adjunct questions.
4. There will be a significant influence on performance for subjects who receive treatments in which they highlight information in the written materials.

Treatments were named according to the type of questions that were inserted into the written passage and whether or not highlighting was performed. Hence, a treatment named "text questions with highlighting (TQ/H)" describes a treatment with text questions inserted into the written passages with subjects assigned to that treatment highlighting textual and diagrammatic information within the passages according to directions provided. Subjects assigned to any one of six treatments (described in Table 2), all completed the same post-test. It is these post-test scores and the percent of text or diagram information highlighted within the written passage that the analysis for instructional main effects was performed.

A two (levels of highlighting) by three (types of inserted questions) analysis of variance test was used to determine if there were significant instructional treatment effects on the various post-test scores. In accordance with Winer (1971), when a significant F ratio occurred between two of the three types of inserted question treatment conditions, a Scheffe test procedure was completed to determine the location of the significant differences.

Acquisition of Relevant and Incidental Information

Information in this study was defined to be relevant when it was the intended answer to the inserted question. All other information was identified as incidental. Hence, questions on the post-test that are the same as those inserted into the written passage become the measures for the acquisition of relevant information. These questions are identified as relevant diagram questions and relevant text questions. The other questions therefore ask for incidental information and are identified as incidental diagram questions and incidental text questions. These four subsets of post-test questions were analyzed to determine the instructional main effects relative to the acquisition of incidental and relevant information.

An inspection of the means for all treatment conditions, as reported in Table 13, identified potential

TABLE 13

MEANS FOR SUBSETS OF POST-TEST QUESTIONS

Treatment Condition	Diagram Questions		Text Questions	
	Relevant	Incidental	Relevant	Incidental
Diagram questions with highlighting	2.58	2.93	1.59	2.21
Text questions with highlighting	1.47	2.90	2.17	2.00
No questions with highlighting	1.50	2.90	1.81	2.68
Diagram questions without highlighting	2.75	3.40	1.18	2.31
Text questions without highlighting	2.20	3.48	2.55	2.45
No questions without highlighting	2.24	3.06	1.18	2.21

between group differences relative to performance on the subsets of post-test questions. The results of the analysis of variance on each set of scores from the subsets of questions are reported in Table 14. Significant between group differences were found for the inserted question treatment condition for both relevant diagram questions (F=6.32, p<.05) and relevant text questions (F=8.94, p<.01). A comparison between pairs of treatment condition groups using the Scheffe test procedure was performed for both the relevant diagram questions (Table 15) and the relevant text questions (Table 16). Subjects who received text questions inserted in the written passages performed significantly better on the relevant text question post-test measure than subjects who received either diagram questions or no questions inserted in the written passages. Furthermore, subjects who received diagram questions inserted in the written passages also performed significantly better on the relevant diagram questions post-test measure than the other subjects. No comparison was made to see if inserted diagram questions had a greater effect upon the acquisition of relevant diagrammatic information than inserted text questions might have upon the acquisition of relevant text information.

No significant differences occurred between treatment conditions and performances on incidental text questions or incidental diagram questions.

TABLE 14

ANALYSIS OF VARIANCE FOR SUBSETS OF POST-TEST QUESTIONS

Source of Variation	df	Diagram Questions				Text Questions			
		Relevant		Incidental		Relevant		Incidental	
		MS	F	MS	F	MS	F	MS	F
Inserted Questions	2	13.61	6.32*	0.80	0.29	17.43	8.94**	0.91	0.35
Highlighting	1	13.89	6.45*	7.54	2.76	2.13	1.09	0.03	0.01
Questions x Highlighting	2	1.71	0.79	0.76	0.28	4.36	2.23	3.35	1.28
Within	179	2.15		2.73		1.95		2.61	

*p<.05
**p<.01

TABLE 15

SCHEFFE TEST FOR DIFFERENCES BETWEEN MEANS OF INSERTED QUESTION TREATMENT CONDITION ON RELEVANT DIAGRAM QUESTIONS

Procedural Step				
Treatment Groups		1 Diagram Questions	2 Text Questions	3 No Questions
	Means	2.67	1.83	1.88
	Number of Subjects	61	59	65
Scheffe S's	Contrasted Pairs	1-2	1-3	2-3
	Difference Between Means	.84	.79	-.05
	Scheffe S	.66	.64	.65
Probability Statements		$P_{12}(.18 \leq \mu_1 - \mu_2 \leq 1.50) = .95$*		
		$P_{13}(.15 \leq \mu_1 - \mu_3 \leq 1.39) = .95$*		
		$P_{23}(-.70 \leq \mu_2 - \mu_3 \leq .60) = .95$**		

*significant difference between contrasted pair

**no significant difference between contrasted pair

TABLE 16

SCHEFFE TEST FOR DIFFERENCES BETWEEN MEANS OF INSERTED QUESTION TREATMENT CONDITION ON RELEVANT TEXT QUESTIONS

Procedural Step		Results of Computations		
Treatment Groups		1 Diagram Questions	2 Text Questions	3 No Questions
	Means	1.38	2.36	1.50
	Number of Subjects	61	59	65
Scheffe S's	Contrasted Pairs	1-2	1-3	2-3
	Difference Between Means	-.98	-.12	.86
	Scheffe S	.63	.61	.62
Probability Statements		$P_{12}(-1.61 \leq \mu_1 - \mu_2 \leq -.35) = .95$*		
		$P_{13}(-.73 \leq \mu_1 - \mu_3 \leq .49) = .95$**		
		$P_{23}(.24 \leq \mu_2 - \mu_3 \leq 1.48) = .95$*		

*Significant difference between contrasted pair

**No significant difference between contrasted pair

A significant difference did occur between highlighting treatment condition relative to performance on relevant diagram questions (F=6.45, p<.05). Generally those subjects who did not highlight within written passages performed significantly better on measures of relevant diagrammatic information than those who performed highlighting activity.

Overall Post-test Performance

Overall post-test performance was calculated by counting the number of items correct within all subsets of post-test questions. The means for these scores by treatment condition is reported in Table 17. While some differences between the means occurred, no significant differences were found between any treatment conditions, as reported in Table 18.

Highlighting Effects

The highlighting activity of subjects was measured in terms of the percentage of sentences of text or the percentage of specifics of a diagram marked with the yellow felt-tip marker. The number of sentences and specific parts of diagrams within each written passage is reported in the coding sheet used in computations of highlighting measures (See Appendix F). The percent of the number of sentences highlighted was computed by dividing the number highlighted by the number of sentences in the written

TABLE 17

MEANS OF POST-TEST MEASURES: TOTAL QUESTIONS

Performance Measure	Highlighting			No Highlighting		
	Diagram Question	Text Question	No Question	Diagram Question	Text Question	No Question
Total Questions	9.31	8.53	8.97	9.66	10.69	8.72

TABLE 18

ANALYSIS OF VARIANCE
TOTAL POST-TEST PERFORMANCE

Source of Variation	df	MS	F
Inserted Questions	2	10.279	0.44
Highlighting/No Highlighting	1	26.196	1.13
Questions x Highlighting	2	24.026	1.04
Within	179	23.154	

passage. (Highlighting all or part of a sentence or specific part was counted as one.) The same procedure was followed for computing the percent of diagrammatic specifics highlighted. These percents, when computed for each written passage (Table 19 and 20), were considered to be repeated measures of highlighting activity across the seven written passages.

An analysis of variance with repeated measures was performed to assess the changes in highlighting activities from passages one through seven. One analysis was performed on percentage of diagrams highlighted and another on percentages of text highlighted. These analyses, as presented in Table 21, disclosed no significant differences for either diagram or text highlighting activity between treatment conditions over all passages. However, a significant interaction occurred between passages and treatment conditions for both the highlighting of diagrams ($F=2.99$, $p<.01$) and the highlighting of text ($F=2.19$, $p<.05$). In accordance with Winer (1971), tests for simple main effects were performed, as reported in Table 22. These tests disclosed significant treatment effects for only one passage for text highlighting (passage 4, $F=5.59$, $p<.01$) and two passages for diagram highlighting (passage 4, $F=5.80$, $p<.01$; passage 7, $F=6.70$, $p<.01$).

Comparisons were performed on the significant passages using the Newman-Keuls procedure (Table 23, 24, and 25). In passage four, treatments receiving inserted diagram questions highlighted significantly more diagram information

TABLE 19

PERCENTAGE OF DIAGRAM HIGHLIGHTED

Source of Variation		Treatment Condition			Cross Treatments
		Diagram Question	Text Question	No Question	
Within Treatment		16.29	7.92	12.57	
Passages x Treatment					
	1	8.07	5.70	7.34	7.03
	2	6.21	6.33	10.78	7.85
	3	11.44	8.23	8.84	9.47
	4	29.48	12.63	9.69	16.97
	5	22.13	11.60	15.62	16.37
	6	16.62	4.90	10.18	10.49
	7	20.03	6.07	25.50	17.35

TABLE 20

PERCENTAGE OF TEXT HIGHLIGHTED

		Treatment Condition			
Source of Variation		Diagram Question	Text Question	No Question	Cross Treatments
Within Treatment		36.20	40.24	42.16	
Passages x Treatment					
	1	38.48	45.30	38.59	40.77
	2	35.41	41.63	41.38	39.56
	3	35.34	46.20	42.28	41.36
	4	45.03	45.60	58.90	50.10
	5	35.48	42.63	44.97	41.48
	6	29.93	30.27	34.47	31.64
	7	33.72	30.03	34.50	32.78

TABLE 21

ANALYSIS OF VARIANCE WITH REPEATED MEASURE FOR TREATMENTS WITH HIGHLIGHTING

Source of Variation	df	Highlighting Diagrams MS	Highlighting Diagrams F	Highlighting Text MS	Highlighting Text F
Between Subjects	90				
Treatments	2	3720.65	1.81	1958.21	0.69
Subjects Within Groups	88	2055.09			
Within Subjects	546				
Written Passages	6	1891.27	6.77**	3374.21	15.63**
Passages x Treatments	12	835.57	2.99**	461.01	2.14*
Passages x Subjects Within Groups	528	279.31		215.82	

*$p < .05$
**$p < .01$

TABLE 22

SUMMARY OF ANALYSIS OF VARIANCE OF HIGHLIGHTING FOR SIMPLE MAIN EFFECTS

		Highlighting Diagrams		Highlighting Text	
Source of Variation	df	MS	F	MS	F
Between Subjects					
Treatments at Passage 1	2	37.30	.07	496.59	.83
Treatments at Passage 2	2	290.91	.54	796.51	1.34
Treatments at Passage 3	2	110.87	.20	1333.69	2.25
Treatments at Passage 4	2	3095.11	5.80**	3312.02	5.59**
Treatments at Passage 5	2	854.74	1.60	1421.71	2.40
Treatments at Passage 6	2	992.89	1.86	517.77	.87
Treatments at Passage 7	2	3574.62	6.70**	353.10	.59
Error between Subjects	616	532.85		592.38	
Within Subjects					
Passages with DQ	6,504	10976.88	39.30**	657.91	3.05**
Passages with TQ	6,522	2474.79	8.86**	1505.72	6.98**
Passages with NQ	6,588	7146.62	25.58**	2237.85	10.37**
Error within Subjects		279.31		215.82	

**p<.01

TABLE 23

TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING DIAGRAM AT PASSAGE FOUR USING THE NEWMAN-KEULS PROCEDURE

Procedural Step		Results of Computations		
Ordered Treatment Groups		1 No Questions	2 Text Questions	3 Diagram Questions
	Means	9.69	12.63	29.48
Contrasted Pairs		1-2	1-3	2-3
	Differences Between Pairs	2.94	19.79**	16.85**
Newman-Keuls Interval			r = 2	r = 3
		$S_A(q_{.95})$	4.40	5.26
		$S_A(q_{.99})$	5.70	6.55

**p<.01

TABLE 24

TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING DIAGRAM AT PASSAGE SEVEN USING THE NEWMAN-KEULS PROCEDURE

Procedural Step		Results of Computations		
Ordered Treatment Groups		1 Text Questions	2 Diagram Questions	3 No Questions
	Means	6.07	20.03	25.50
Contrasted Pairs		1-2	1-3	2-3
	Differences Between Pairs	13.96**	19.43**	5.47*
Newman-Keuls Interval			r = 2	r = 3
		$S_A(q_{.95})$	4.40	5.26
		$S_A(q_{.99})$	5.70	6.55

*p<.05
**p<.01

TABLE 25

TESTS FOR DIFFERENCES BETWEEN MEANS OF HIGHLIGHTING TEXT AT PASSAGE FOUR USING THE NEWMAN-KEULS PROCEDURE

Procedural Step		Results of Computations		
Ordered Treatment Groups		1 Diagram Questions	2 Text Questions	3 No Questions
	Means	45.03	45.60	58.90
Contrasted Pairs		1-2	1-3	2-3
	Differences Between Pairs	.57	13.38**	13.30**
Newman-Keuls Interval			r = 2	4 = 3
		$S_A(q_{.95})$	4.65	5.56
		$S_A(q_{.99})$	6.12	6.92

**p<.01

(p<.01) than other treatment conditions. Also, treatments with no inserted questions highlighted significantly more textual information (p<.01) than other treatments. In passage seven, treatments with text inserted questions highlighted significantly less (p<.01) diagram information than other treatments.

An alternative view of the effect of different instructional treatments upon the amount of information highlighted is furnished by the within group analysis of the changes from a base rate of highlighting activity across subsequent written passages, as reported in the analysis for simple main effects, Table 22. An increase in highlighting activity was found to be significant for all treatment conditions (p<.01) for diagram information. Decreases were found to be significant for highlighting text information for all treatments (p<.01). The effects of these treatment conditions upon highlighting activity are illustrated in Figure 1 and 2.

Aptitude x Treatment Interactions

The following hypothesis was of major concern relative to aptitude x treatment interactions:

1. There will be a differential relationship between criterion performances and aptitudes of subjects, relative to the treatment received.

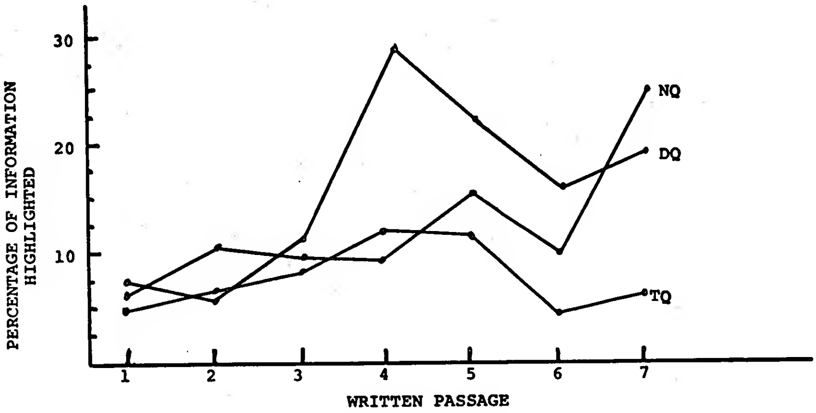


Figure 1: Percentage of Information Highlighted in Diagrams

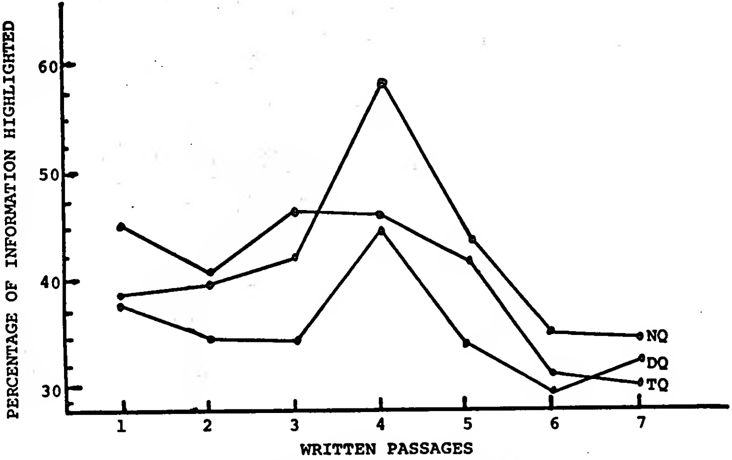


Figure 2: Percentage of Information Highlighted in Text

Correlations of Ability Measures to Performance

The major purpose of this study was to examine the effects of individual differences in relation to acquisition of relevant and incidental information from written materials containing two modes of instructional content. In terms of the model previously proposed by Melton (1967) for investigating individual differences in learning, ability-performance relationships may be expected to vary as a function of the nature of the task. It was anticipated that the requirements of learning from a textual mode and a diagrammatic mode of information presentation were sufficiently different to produce different ability-performance relationships.

A first step in evaluating these theoretically expected relationships was to compute for each group separately, the correlations between all aptitudes and the post-test performance measures. The correlations were then reassembled by post-test measure so that the correlations for a specified measure for all treatments would appear within the same table in order to facilitate inspection. These individual treatment group correlations are reported in Tables 26 through 30. Upon inspection it was apparent that in several instances the correlations between aptitudes and performance measures varied substantially across treatment conditions. Aptitude variables were then selected for further investigation of aptitude x

TABLE 26

INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR RELEVANT DIAGRAM QUESTIONS

	Highlighting			No Highlighting		
Predictor	Diagram Questions	Text Questions	No Questions	Diagram Questions	Text Questions	No Questions
Vocabulary, Part 1	.49	.25	.28	.27	.26	.54
Vocabulary, Part 2	.35	.28	.35	.29	.11	.66
Vocabulary, Total	.45	.28	.35	.30	.17	.63
Number Comparison, Part 1	-.06	.03	-.04	.18	.57	.42
Hidden Patterns, Part 1	.15	.34	.09	.01	.45	.54
Object-Number	-.01	-.01	-.01	.07	.07	-.02
Treatment Time	.22	-.08	.36	-.12	.18	-.34
Test Time	.06	.01	-.19	-.04	.01	-.29
Inserted Questions	.85	.28	--	.89	.43	--

r(<.05) = .146

TABLE 27

INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR INCIDENTAL DIAGRAM QUESTIONS

	Highlighting Treatments			No Highlighting Treatments		
Predictor	Diagram Questions	Text Questions	No Questions	Diagram Questions	Text Questions	No Questions
Vocabulary, Part 1	.53	.39	.39	.52	.30	.48
Vocabulary, Part 2	.64	.42	.23	.52	.42	.46
Vocabulary, Total	.63	.43	.35	.55	.43	.49
Number Comparison, Part 1	.06	.29	.16	.19	.22	.20
Hidden Patterns, Part 1	.36	.45	.12	.34	.47	.11
Auditory Letter Span	.13	.33	.01	.16	.54	-.04
Object-Number	.03	.15	.24	-.11	.26	-.03
Treatment Time	.05	-.17	.16	-.31	.20	-.16
Test Time	-.01	.01	.02	-.39	-.05	-.38
Inserted Questions	.63	.31	--	.30	.36	--

r(<.05) = .146

TABLE 28

INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR RELEVANT TEXT QUESTIONS

	Highlighting Treatments			No Highlighting Treatments		
Predictor	Diagram Questions	Text Questions	No Questions	Diagram Questions	Text Questions	No Questions
Vocabulary, Part 1	.47	.51	.39	.48	.14	.45
Vocabulary, Part 2	.55	.50	.16	.55	.35	.57
Vocabulary, Total	.56	.53	.31	.55	.34	.54
Number Comparison, Part 1	.01	.47	.04	.03	-.07	.21
Hidden Patterns, Part 1	.42	.37	.15	.18	-.01	.34
Auditory Letter Span	.19	.62	-.02	.11	.38	.22
Object-Number	.00	.47	.06	-.31	.21	.13
Treatment Time	-.00	-.43	.37	-.34	.34	-.23
Test Time	-.10	.35	-.23	-.22	.01	-.02
Inserted Questions	.50	.71	--	.26	.54	--

$r(<.05) = .146$

TABLE 29

INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR INCIDENTAL TEXT QUESTIONS

	Highlighting Treatments			No Highlighting Treatments		
Predictor	Diagram Questions	Text Questions	No Questions	Diagram Questions	Text Questions	No Questions
Vocabulary, Part 1	.40	.40	.28	.52	.15	.42
Vocabulary, Part 2	.40	.37	.18	.49	.49	.62
Vocabulary, Total	.43	.42	.26	.53	.42	.54
Number Comparison, Part 1	.24	.06	.04	.28	.03	.15
Hidden Patterns, Part 1	.20	.20	.13	.11	.38	.29
Auditory Letter Span	.14	.38	-.07	-.02	.26	-.02
Object-Number	.11	.22	.15	-.09	.09	-.01
Treatment Time	-.12	-.10	.33	-.34	.33	-.12
Test Time	.11	-.23	-.16	-.22	.10	-.31
Inserted Questions	.25	.32	--	.45	.39	--

$r(<.05) = .146$

TABLE 30

INDIVIDUAL TREATMENT GROUP CORRELATIONS FOR OVERALL POST-TEST PERFORMANCE

Predictor	Highlighting Treatments			No Highlighting Treatments		
	Diagram Questions	Text Questions	No Questions	Diagram Questions	Text Questions	No Questions
Vocabulary, Part 1	.59	.49	.44	.56	.28	.57
Vocabulary, Part 2	.61	.50	.32	.58	.48	.70
Vocabulary, Total	.65	.52	.43	.61	.47	.67
Number Comparison, Part 1	.06	.28	.06	.22	.22	.30
Hidden Patterns, Part 1	.35	.43	.16	.20	.42	.38
Auditory Letter Span	.15	.52	-.10	.13	.47	.01
Object-Number	.03	.27	.17	-.13	.22	.00
Treatment Time	.05	-.25	.42	-.35	.36	-.26
Test Time	.01	.04	-.19	-.28	.02	-.33
Inserted Questions	.72	.50	--	.59	.58	--

r(<.05) = .146

treatment interaction when they demonstrated a variation across treatment conditions of about .40 between two or more correlations and when the majority of the correlations were significantly different from zero.

Evaluation for Aptitude x Treatment Interactions

Aptitude x treatment interactions were evaluated by comparing regression slopes for different treatments, using F tests for heterogeniety of regression. Although many F tests were calculated and few were significant, generally those F tests that were significant followed closely to the theoretically expected relationships.

A basic consideration of aptitude x treatment interaction is the notion that instructional treatments be adapted to the individual differences of the learner. However, instruction can be adapted only when there are alternative treatments leading to the same terminal objective, and only if the regression of criterion scores on aptitude scores of one treatment intersects the regression for an alternative treatment (Cronbach, 1965). Consequently, while the results of all computed regression analyses are reported, only those analyses which disclosed significant interactions have been presented in graphic form. Subsequent discussion and interpretation of these interactions were based upon the illustrations.

Acquisition of Relevant and Incidental Information from Diagrams

Results of regression analysis for aptitude x treatment interaction using the scores on relevant and incidental diagram questions as the performance measure, are summarized in Table 31. These results disclosed that treatment time and relevant diagram questions produced significant interactions (F=2.30, p<.01). This interaction is illustrated in Figure 3. For treatment conditions with inserted diagram questions with highlighting (DQ/H), inserted text questions without highlighting (TQ/NH), and no inserted questions with highlighting (NQ/H), treatment was positively related to scores on relevant diagram questions and hence subjects assigned to these treatments exhibited a higher level of acquisition as they spent more time in the treatment. For treatment conditions with no inserted questions without highlighting (NQ/NH), a negative relationship was observed and hence subjects assigned to this treatment generally performed better when they took less time. Treatment conditions with inserted diagram questions without highlighting (DQ/NH) and inserted text questions with highlighting (TQ/H) displayed almost no relationship between performance on relevant diagram questions and treatment time. In addition, the specific interaction between the two no inserted questions treatment conditions, with highlighting and without highlighting

TABLE 31

SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF DIAGRAM QUESTIONS

Predictor	Highlighting Treatments						No Highlighting Treatments						F
	Diagram Questions		Text Questions		No Questions		Diagram Questions		Text Questions		No Questions		
	a	b	a	b	a	b	a	b	a	b	a	b	
Relevant Diagram Questions													
Vocabulary, Total	.44	.12	.27	.07	.25	.07	1.53	.07	1.65	.03	-.52	.15	1.50
Number Comparison, Part 1	2.86	-.02	1.37	.01	1.65	-.01	1.95	.08	-.26	.26	.23	.16	2.12
Hidden Patterns, Part 1	1.88	.03	.27	.04	1.16	.01	2.71	.00	.63	.06	-.31	.09	1.63
Treatment Time	1.16	.05	1.89	-.02	-.41	.10	3.34	-.03	1.51	.03	3.64	-.09	2.30*
Inserted Questions	-.16	.91	.87	.23	--	--	.73	.67	1.05	.37	--	--	5.41**
Incidental Diagram Questions													
Vocabulary, Part 2	.40	.29	.65	.24	1.96	.11	1.27	.26	1.75	.19	.96	.23	.64
Auditory Letter Span	2.32	.11	1.14	.32	2.87	.01	2.45	.17	1.59	.35	3.37	-.05	1.19
Treatment Time	2.58	.01	4.11	-.05	1.83	.05	5.08	-.08	2.56	.05	3.76	-.04	1.25
Test Time	2.99	-.01	2.88	.00	2.75	.02	4.96	-.15	3.74	-.02	5.14	-.17	1.52

*$p<.05$
**$p<.01$

Note: a and b are of the form: $\hat{y} = a + bx$

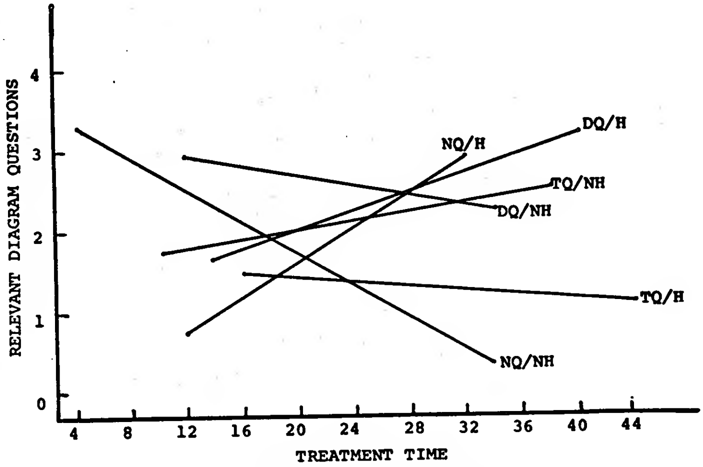


Figure 3: Interaction of Treatment Time With Relevant Diagram Questions

(NQ/H, NQ/NH), appears to be a disordinal interaction with an intersection at about twenty minutes.

The number of inserted questions answered correctly and the performance on relevant diagram questions also produced significant interactions (F=5.41, p<.01). Scores for all treatments with inserted questions were positively related to scores on relevant diagram questions. While subjects in treatments with inserted diagram questions exhibited only a slight advantage over subjects with inserted text questions, generally the slopes of the inserted diagram questions were steeper than those for treatments with inserted text questions. The generally positive relationship between inserted questions and performance on relevant diagram questions indicates that subjects answering more inserted questions exhibit better performances on the post-test, even when the questions are dissimilar to the inserted ones. This interaction is illustrated in Figure 4.

No significant interactions were disclosed for incidental diagram questions.

Acquisition of Relevant and Incidental Information from the Texts

Regression analysis using scores on relevant and incidental text questions as performance measures are summarized in Table 32. These analyses show significant interactions for the object-number aptitude measure (F=2.52, p<.05), treatment time (F=4.06, p<.01), and

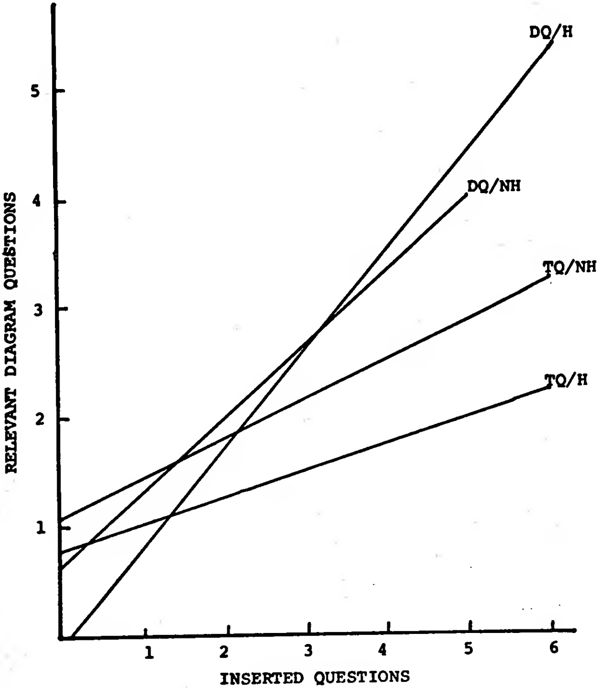


Figure 4: Interaction of Inserted Questions With Relevant Diagram Questions

TABLE 32

SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF TEXT QUESTIONS

	Highlighting Treatments						No Highlighting Treatments						
	Diagram Questions		Text Questions		No Questions		Diagram Questions		Text Questions		No Questions		
Predictor	a	b	a	b	a	b	a	b	a	b	a	b	F
Relevant Text Questions													
Vocabulary, Part 1	-.35	.23	-.46	.28	.69	.14	-.59	.21	1.95	.07	.09	.13	1.17
Number Comparison, Part 1	1.55	.00	.17	.18	1.64	.02	1.04	.01	2.98	-.04	.67	.05	1.26
Auditory Letter Span	.77	.14	-.68	.51	1.89	-.01	.65	.10	1.14	.25	.34	.14	2.01
Object-Number	1.58	.00	.99	.23	1.64	.03	1.76	-.11	2.01	.09	.95	.04	2.52*
Treatment Time	1.59	.00	4.78	-.10	-.16	.10	2.73	-.07	.89	.08	1.80	-.04	4.06**
Inserted Questions	.17	.47	.36	.69	--	--	.94	.08	.64	.60	--	--	3.04*
Incidental Text Questions													
Vocabulary, Part 2	.89	.15	.33	.18	1.83	.10	.09	.26	.26	.24	-.43	.28	.92
Treatment Time	2.87	-.03	2.61	-.02	.29	.12	4.34	-.10	.81	.08	2.71	-.03	2.65*
Inserted Questions	1.56	.21	1.21	.30	--	--	1.04	.41	1.04	.45	--	--	.34

*p<.05
**p<.01

Note: a and b are of the form: $\tilde{y} = a + bx$

inserted questions (F=3.04, p<.05). Treatment time also produced significant interactions with incidental text questions (F=2.65, p<.05).

The effects of object-number measures upon post-test performance is illustrated in Figure 5. Object-number aptitude measure is a measure of associative memory. Generally, treatments with inserted text questions with or without highlighting (TQ/H, TQ/NH) were positively related to high performance on relevant text questions. The treatment with inserted diagram questions without highlighting (DQ/NH) was negatively related while other treatments demonstrated either a weak or non-existant relationship. It is also interesting to note that regression lines for treatments with inserted text questions are generally steeper and higher than those for inserted diagram questions.

As illustrated in Figure 6, treatment time exhibited a strongly positive relationship to performance on relevant text questions for treatments with inserted text questions without highlighting (TQ/NH), and no inserted questions with highlighting (NQ/H). The steep and generally higher regression lines for these treatments would suggest that subjects assigned to these treatments would not only benefit from increased time spent in the treatment, but also that they generally performed better than subjects in other treatments. A negative relationship was found between performance and treatment time for treatments with

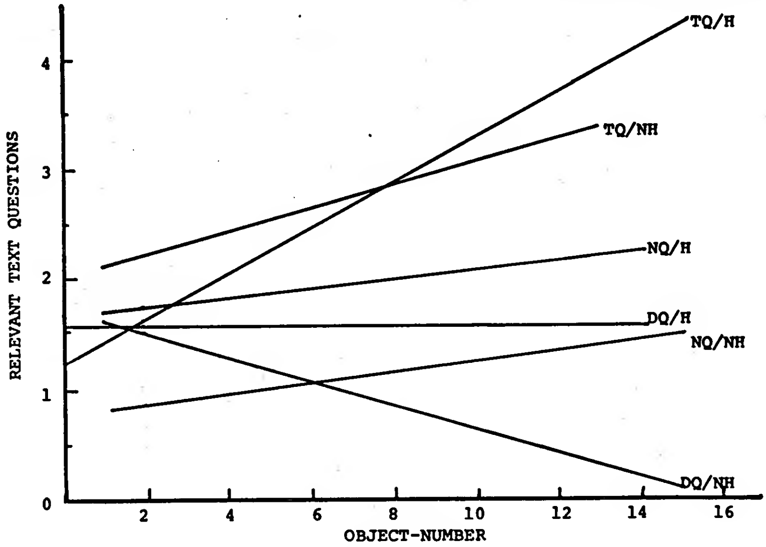


Figure 5: Interaction of Object-Number With Relevant Text Questions

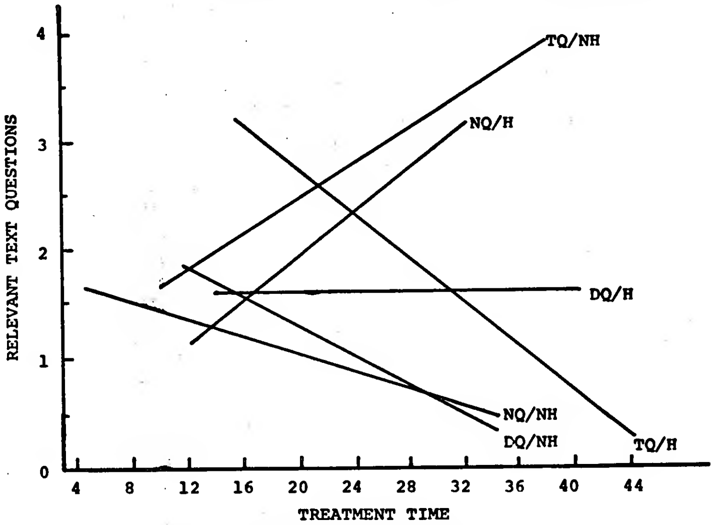


Figure 6: Interaction of Treatment Time With Relevant Questions

inserted text questions and highlighting (TQ/H), inserted diagram questions without highlighting (DQ/NH), and no inserted questions without highlighting (NQ/NH) indicating that additional time spent in the treatment did not produce higher performance on the relevant text questions. The treatment with inserted diagram questions and highlighting (DQ/H) exhibited no relationship to time.

The number of inserted questions answered correctly was positively related, as illustrated in Figure 7, to all treatments, but strongly related to treatments with inserted text questions as these were the same as the relevant text questions on the post-test. However, answering inserted questions, even when they were diagram questions when accompanied with highlighting also seemed to facilitate a higher performance on post-test performance on relevant text questions. An exception seems to be the treatment with inserted diagram questions without highlighting (DQ/NH). Here a relationship is almost non-existant between inserted questions and performance.

Post-test performance on incidental text questions is considered to be a measure of incidental learning. The effects of treatment time on this performance, as illustrated in Figure 8, indicates that treatment conditions with no inserted questions and highlighting (NQ/H) and text questions without highlighting (TQ/NH) have a facilitative effect upon incidental learning. All other treatments are negatively

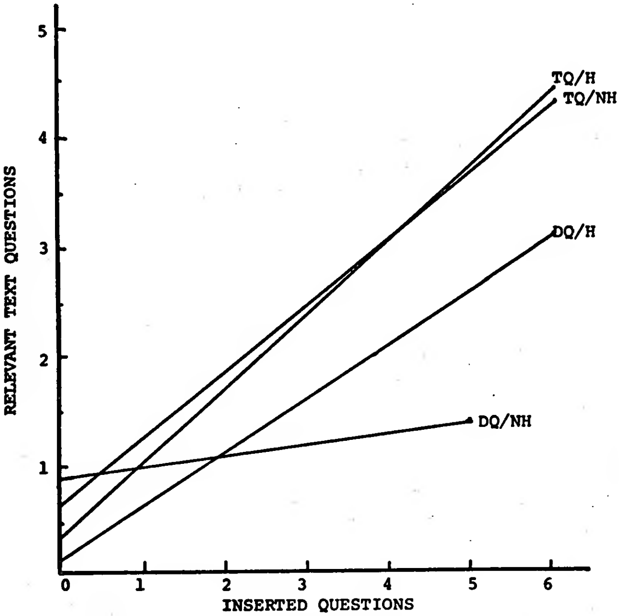


Figure 7: Interaction of Inserted Questions With Relevant Text Questions

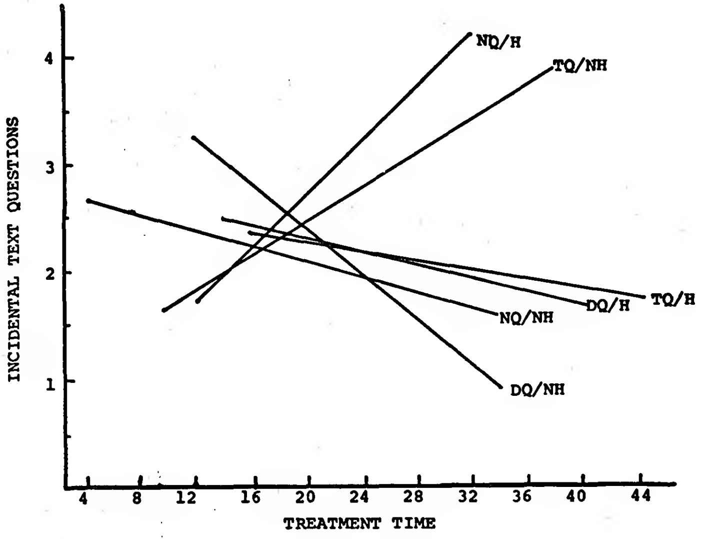


Figure 8: Interaction of Treatment Time With Incidental Text Questions

related, especially inserted diagram questions without highlighting (DQ/NH) which demonstrated a strong negative relationship.

Overall Post-test Performance

Results of regression analysis using the total of all post-test questions as a performance measure are summarized in Table 33. These analyses show that scores on treatment time and total post-test questions interacted significantly ($F=3.49$, $p<.05$). This interaction is illustrated in Figure 9. Generally, treatment time was positively related to scores on total post-test performance for treatment conditions with text questions without highlighting (TQ/NH) and no questions with highlighting (NQ/H), and negatively related to treatment conditions with no questions without highlighting (NQ/NH), diagram questions without highlighting (DQ/NH), and text questions with highlighting (TQ/H), while diagram questions with highlighting (DQ/H) displayed almost no relationship. Therefore subjects assigned to either treatments with text questions without highlighting (TQ/NH) or no questions with highlighting (NQ/H) were able to perform better on the post-test when they spent more time in the treatment. Subjects assigned to treatments diagram questions without highlighting (DQ/NH), or no questions without highlighting (NQ/NH) and text questions with highlighting (TQ/H) generally performed better when they spent less time in the treatment.

TABLE 33

SLOPES AND INTERCEPTS FOR LINEAR REGRESSION OF TOTAL POST-TEST QUESTIONS

	Highlighting Treatments						No Highlighting Treatments						
	Diagram Questions		Text Questions		No Questions		Diagram Questions		Text Questions		No Questions		
Predictor	a	b	a	b	a	b	a	b	a	b	a	b	F
Auditory Letter Span	7.25	.36	1.00	1.37	10.34	-.23	7.31	.41	5.88	.88	8.50	.04	1.71
Treatment Time	8.21	.04	13.39	-.19	1.29	.38	18.50	-.28	5.76	.24	12.00	-.21	3.49*

*$p<.05$

Note: a and b are of the form: $\tilde{y} = a + bx$

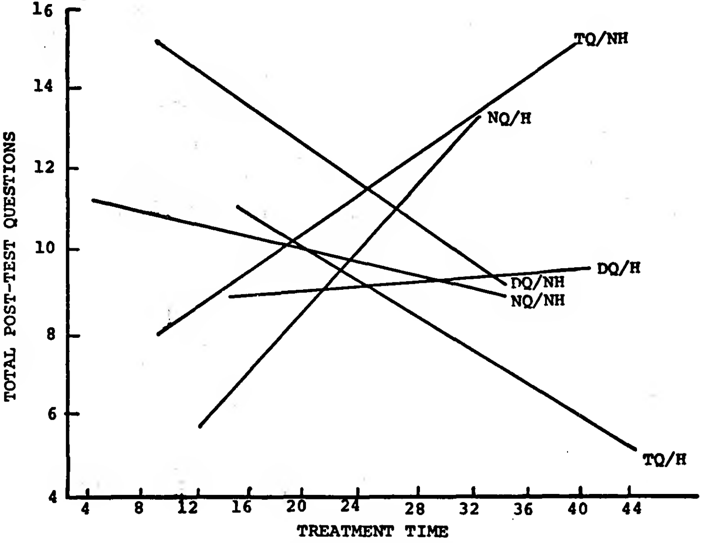


Figure 9: Interaction of Treatment Time With Total Post-test Questions

CHAPTER IV

DISCUSSION AND IMPLICATIONS

Summary of Data: Hypotheses Tests

This study sought to examine the effects of verbal and perceptual aspects of learner aptitude, in relation to inspection behavior performed while learning from written materials containing two modes of instructional content. Some general premises basic to this study include the following:

1. The physical stimulus presented to the learner during instruction is not in simple correspondence to the effective stimulus encoded by the learner, and that it is the effective stimulus which becomes the basis for subsequent psychological learning activity.
2. The various internal processing activities which contribute to the encoding of an effective stimulus can be influenced by elements in the physical stimulus. Therefore, acquisition of information from an instructional situation varies as a function of the prompts and cues included in the instructional material and environment.

3. The effectiveness of different instructional material varies from individual to individual with differences being correlated with individual aptitudes.

Specific predictions, although tentative, were based on theoretical considerations which suggest that requirements of different modes of instructional content were sufficiently different to produce different ability-performance relationships.

Instructional Treatment Main Effects

Acquisition of relevant information.--The first hypothesis tested was:

1. Subjects receiving treatments with adjunct questions inserted into the written passage will exhibit greater acquisition of relevant information than the control group.

As previously defined, information is identified as relevant when it is the intended response to an inserted question. Therefore, when a subject can respond correctly to the relevant post-test questions, which are identical with the inserted question, his performance is evidence for the acquisition of relevant information. Support for this hypothesis is dependent upon significant between group differences in scores on relevant post-test questions. The appropriate statistical tests of this hypothesis are therefore comparisons of performances on relevant text or diagram questions by pairs of treatment conditions following an overall significant F ratio. The data in Table 14 strongly supported this hypothesis.

In general, when subjects answered questions within the written passage, they also performed better on those same questions on the post-test than subjects who did not receive the questions within the written passage. Hence, subjects who received inserted diagram questions also performed better on the relevant diagram questions on the post-test. The same was true of subjects receiving inserted text questions in that their performance was better than other subjects on relevant text questions on the post-test. This finding is consistent with earlier studies (Rothkopf, 1966; Rothkopf and Bisbicos, 1967; Frase, 1970) where it was shown that the insertion of questions in written instructional material increases the amount learned from the text when they occur after the written passage to which they relate.

The facilitative effects of questions appearing after the written passage upon the acquisition of relevant information is often identified as a direct instructional effect of questions. This effect recognizes that the content load of the question itself provides additional opportunity for the acquisition of that information in subsequent questions with similar content loads. The repetition and practice learners perform when responding to content-loaded questions would suggest that a relationship should exist between answering the question correctly and the performance on the relevant post-test questions. This expectation was confirmed by regression analysis where positive relationships were disclosed between the number of inserted questions answered and the performance on the corresponding relevant questions. This relationship occurred for both inserted diagram and inserted text questions treatment conditions (Figure 4 and 7).

In summary, both the significant between-group differences and the positive relationships between performances on inserted questions and relevant post-test questions support the hypothesis that inserted questions facilitate acquisition of the relevant information from both diagrams and text. In addition, the mechanism involved in both cases can be identified as the direct instructional effects of the content load of the inserted questions on inspection behavior and subsequent acquisition of similar content in passages that follow.

Acquisition of incidental information.--The second and third hypotheses tested were:

2. Subjects receiving treatments with adjunct questions based upon diagrammatic information inserted into the written material will exhibit significantly greater acquisition of incidental information from diagrams than groups that did not receive diagrammatic adjunct questions.

3. Subjects receiving treatment with adjunct questions based upon textual information inserted into the written passage will exhibit significantly greater acquisition of incidental information from text than groups that did not receive textual adjunct questions.

Information is considered to be incidental when it is not an intended response to the questions inserted into the written passages. Acquisition of incidental information is measured by performance on post-test questions that are not the same as those inserted into the written passage. While the inserted questions also appearing on the post-test are called relevant post-test questions, these are called incidental post-test questions. Support for these hypotheses is dependent upon significant between-group differences in scores on incidental post-test questions. The appropriate statistical tests of these hypotheses are therefore comparisons of performances on incidental text or diagram questions by pairs of treatment conditions following an overall significant F ratio. The data in Table 14 were collected to test these hypotheses. However, the non-significant F ratios for between-group differences on incidental post-test questions for both diagram and text information fail to support hypotheses 2 and 3.

Evidence for incidental learning is measured on post-test questions that are not the same as those inserted into the text. Therefore, two additional performances should be considered; first, performances on relevant text questions when the treatment condition was inserted diagram questions, and second, performances on relevant diagram questions when the treatment condition was inserted text questions. The comparisons of these performances reported in Table 15 and 16 disclose that treatments with inserted text questions did not perform significantly better on the relevant diagram questions than treatment conditions with no inserted questions. The lack of significance was also found between treatments with inserted diagram questions and no inserted questions relative to their performance on the relevant text questions. This additional evidence also fails to support hypotheses 2 and 3.

The effects of inserted questions in written passages provides a means to contrast acquisition of relevant and incidental learning. While the analysis of variance and subsequent comparisons proved to be insignificant, regression analysis between the number of inserted questions and the performance on another set of relevant post-test questions was generally positive. Here, treatments with inserted text questions displayed a positive relationship to performance on relevant diagram questions but regression slopes were somewhat less steep and not as high as treatments with inserted diagram questions (Figure 4). A similar relationship (Figure 7) occurs between treatment conditions with inserted diagram questions and their performance relative to relevant text questions. These observations are consistent with the observation that an additional multiplier is involved when considering the relative facilitative effects of inserted questions upon relevant versus incidental learning.* This multiplier refers to the fact that the relevant information, as measured by the relevant post-test questions, represents fairly limited sized population of content while the incidental information, represents a much larger sized universe of content. Subjects in the treatment groups with the relevant inserted questions are cued to the information necessary for acquisition in order to produce better post-test performances. Therefore, they can attend to less information than subjects in other treatments would have to consider in order to achieve the same post-test performance. It is therefore hard to tell how powerful the influence of inserted questions really is on these two performances, even when the post-test questions are the same.

In summary, the evidence collected does not generally support hypotheses 2 and 3. However, inserted questions may have actually exerted a great influence on the acquisition of incidental information. Partial explanation of this lies in the fact that the incidental post-test questions have sampled only a very small portion of the incidental content as compared to the 100 percent sampling of the relevant content.

---

*E. Z. Rothkopf, personal communication.

Highlighting effects.--The fourth hypothesis tested was:

4. There will be a significant influence on performance for subjects who receive treatments in which they highlight information in the written materials.

Support for this hypothesis is dependent upon significant between group differences in post-test scores for groups that highlighted and those that did not. The appropriate statistical test of this hypothesis is a significant F ratio. Data in Table 14 indicated that subjects who did not highlight diagrams performed significantly better on the relevant diagram questions than those who did highlight diagrams. No significant differences were found between those who highlighted text and those who did not, even though the means for highlighting text groups were generally lower than the non-highlighting text groups.

Further analysis of highlighting activity by applying a repeated measures analysis using the amount of information highlighted as the repeated measure across written passages revealed that the change in the percent of information highlighted from the base rate for passage one increased for diagrams but decreased for texts. Another analysis using regression techniques comparing time spent in the treatment to performance on relevant post-test questions revealed that highlighting activity and performance were confounded with the time spent in the treatment. Generally, when subjects in treatment conditions that included highlighting activity spent little time in the treatment, their performances were generally poorer on the post-test questions than subjects who spent more time. However, when they spent less time without highlighting, their performances improved (Figure 3). Since highlighting activity for diagrams increased across the written passages, the amount of time required to do the highlighting would also increase. The chance exists that the activity of highlighting may occur without attending to detail and in some cases the subject's attention may have been placed on the activity of highlighting itself.

When highlighting and no highlighting were compared using regression analysis for treatment conditions without questions, an interesting, potential disordinal interaction occurred (Figure 3) between treatment time and performance on relevant diagram questions. When a short time was spent studying written materials (treatment time), subjects benefited most by not spending the extra effort or time trying to highlight important information. However, highlighting provided a chance to facilitate acquisition when study time in the treatment exceeded about twenty minutes. While highlighting may hinder the subject's inspection activity during a short study time, highlighting seemed to facilitate performance during longer time periods. This facilitative effect may be due to the influence of highlighting activity to maintain the focus of attention during long periods of time when the tendency would be to shift the focus of attention to distractions.

In summary, highlighting activity seems to inhibit performance on relevant post-test questions, according to differences between group means. However, when highlighting occurred without any inserted questions, a positive relationship occurred between time and relevant post-test performance, indicating that highlighting potentially may exert an influence upon inspection behavior in a similar manner as inserted questions. When combined with inserted questions, the effects of highlighting are not always positive and in some cases inhibit performance, as reflected by differences between mean performances. While the beneficial effects of highlighting, when they occur, have been interpreted as a means to focus attention to important specifics, this type of treatment was found to interfere with the achievement of high performances. This finding is consistent with studies where a high amount of repetition or attention to detail failsto produce the higher performance (Rothkopf and Coke, 1966; Rothkopf, 1968). Evidentally, in the practice of highlighting activity, the learner may read the passage and then go back and highlight (often immediately) what he considered to be important. It may well be that this unmeasured delay in highlighting, when it occurs, is an important variable confounded with highlighting.

Aptitude x Treatment Interactions

The fifth hypothesis tested was:

5. There will be a differential relationship between criterion performances and aptitudes of subjects, relative to the treatment received.

This hypothesis implies disordinal interactions between aptitude and treatment. More specifically, the regression line relating aptitude to criterion scores under one treatment intersects the regression line for the alternative treatment. The statistical tests of this hypothesis are significant F tests for heterogeneity of regression (Cronbach and Snow, 1969).

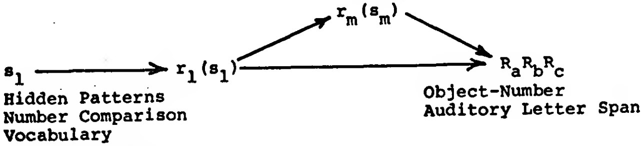
The evidence with respect to hypothesis 5 consists primarily of interactions between treatment time and post-test performance and one aptitude factor test interacting with post-test performance. While treatment time may seem to be an unlikely aptitude, aptitude has been defined as _any_ characteristic of the learner which facilitates or interferes with his learning from some designated instructional method (Cronbach and Snow, 1969).

Treatment time.--Analysis of treatment time with respect to post-test performance revealed that treatments with text questions without highlighting and no inserted questions with highlighting displayed a consistently positively relationship with performance on both relevant and incidental post-test questions. Hence, subjects who spent more time in the treatment generally scored higher when assigned to these treatment conditions. Of special interest are treatments of no inserted questions without highlighting, inserted text questions without highlighting, and inserted diagram questions without highlighting which demonstrated consistently negative relationships between treatment time and post-test performance on relevant and incidental information as well as on an overall post-test performance. When subjects spent more time in these treatments, their performances attenuated.

Taken as a whole, the patterns of treatment time and performance relationships suggests that the effects of questions inserted into the written passages or highlighting can facilitate acquisition. However, when both are present, a heavy burden is placed upon the physical doing within the treatment materials producing in some cases a poorer performance suggesting that the treatment has interfered with effective processing of the material or attenuated performance through boredom or fatigue. A similar effect was observed for treatments with only inserted diagram questions and no inserted questions. Evidentally, these conditions provide little influence and,as a result the learner adapts less productive behaviors, at least in terms of time.

In summary, how a learner spends his time acquiring information from instructional material is of basic importance when it can be shown that time and performance are concomitant variable within instructional conditions.

Aptitude factors.--The initial aptitude factors for this study were selected on the basis of an analysis of learning from diagrammatic and textual mode of instructional material, identifying the tasks and processes corresponding to a model proposed by Melton (1967) for the investigation of learning and individual differences. A summary of individual differences, identified by the aptitude factor tests utilized, is presented below (summarized from page 26).



Organization of Aptitude Factor Tests in a Multi-process Model of Learning

Of the five aptitude factors studied, only the object-number factor test was found to significantly interact with treatment conditions, relative to performance on the relevant text questions. An analysis of this interaction with the relevant text questions (Figure 5) indicates that subjects who scored high on the object-number test also benefited most from treatments with text questions with or without highlighting activity and least from diagram questions without highlighting.

The object-number test of associative memory presents explicit pairs of objects and numbers that the subjects are asked to learn. They are told, in taking the test, that they will be allowed to study the list of object-number pairs and then will be asked to write the number for the same objects, but only arranged in a different order. Hence, the nature of the associations to be formed is quite clear for this particular test as well as for other tests of associative memory (French, Ekstrom, and Price, 1963). However, in learning from written materials, subjects must identify the meaningful associative pairs within or between sentences and then commit them to memory. In the present experiment, questions could conceivably be formed from nearly every sentence. The cues provided by text questions identify important associated information and permit subjects to capitalize on associative memory. In other words, the insertion of questions serve to clarify the nature of the associations to be formed and thus allow associative memory to be more effectively utilized. This finding is consistent with other research (Koran, M. L. and Koran, J. J., 1972) where treatment conditions with high frequency of inserted questions displayed a positive relationship between incidental post-test questions and the scores on the first-last names test of associative memory. The fact that individual differences have more often been found for incidental learning than relevant learning has been presumed to be caused by the higher motivation to learn relevant information, thus obscuring differences in learner habits and sets (Plunderleith and Postman, 1957). However, most other research that has found these differences for incidental learning utilized college aged subjects, rather than the younger high school aged subjects used in this study. It is possible that in the latter case subjects are less motivated to participate, especially when the written materials are not part of their regular school work. It is also possible that the high level of the question difficulty has also limited the effectiveness of inserted questions.

The relationship between associative memory and processing of textual material was predicted in the analysis in Chapter I using Melton's Model (1967). Another relationship was also predicted between perceptual speed and learning from diagrams. Specifically, diagrams can be described as a presentation of specifics within an organizational schema of associations, namely the proximity and sequence of the specifics within the diagram. Here, stimulus differentiation is required in order to assess associations between symbols. Acquisition becomes dependent upon the subjects' perceptual speed and accuracy in scanning these specifics. The number comparison test was identified as a suitable measure of perceptual speed and accuracy. In this test, subjects are presented with 50 pairs of numbers (usually longer than six digits each). The subject was to identify those pairs that are not the identical pairs in a very short period of time. Here also both speed and accuracy of perception are important.

In Table 31, an interaction of borderline significance is reported between number comparison factor test and treatment conditions, in relation to performances on relative diagram questions. An analysis of this interaction indicates that performances in treatment conditions with diagram questions with highlighting generally performed better but without a strong relationship to perceptual speed and accuracy. The same was found for all other treatments with highlighting. Evidentally, highlighting activity as well as diagram questions minimize the demands upon perceptual speed and accuracy and permit subjects to capitalize on other aptitudes in the processing of the diagrammatic information. When these prompts are not present in the treatment conditions, such as inserted text questions without highlighting or no questions with no highlighting, performances place a higher burden on perceptual speed and accuracy, as evidenced by steeper slopes. These latter treatments require subjects to find and accurately identify important information within the diagram without support of the treatment condition.

In summary, highlighting in general inhibited the acquisition of relevant diagram information. However, it was found to benefit certain low ability learners, perhaps by reducing certain processing requirements as well as enabling them to capitalize upon others. In this sense, the treatment condition provided compensation for deficient attentional and perhaps discriminational skills.

Individual Differences in Learning Relevant and Incidental Information

This research has attempted to further examine the relationships between individual differences and inspection behavior relative to learning from different modes of instructional content. In order to search out these relationships, treatments must be designed that capitalize upon the individual learner's habits and learning set. Treatments that strongly influence these habits and learning set usually fail to expose learner characteristics and performance relationships. Therefore, the fact that the treatments in this study displayed no major significant advantage for one over another indicates that they may be suited for the investigation of aptitude x treatment interaction.

Interesting direct instructional effects disclosed that inserted questions with their intended responses selected from diagrams were an effective means to influence acquisition of the intended, relevant information from the diagram. An additional phenomena was observed. Answering most of the inserted text questions also facilitated acquisition of diagrammatic information. However, answering most of the inserted diagram questions did not necessarily facilitate acquisition of relevant text information, unless the task also included the performance of highlighting activity. This observation leads to the possibility that the processing activities are performed differentially.

Generally, processing activity refers to the manipulations performed by the learner in transforming the physical stimulus to an encoded stimulus. When he inspects and attends to some material, it is assumed that this action influences the nature of the encoded stimulus. While inspection and other processing activities are considered to be sensitive to external influence, the effects of this external influences seems to occur differentially, relative to the individual differences in aptitude and performance. In addition, the effects of different modes of instructional content seem to increase these differential effects. Hence, learners may be performing one type of processing activity with diagrams and another for texts.

How inspection behavior is influenced and shaped by external influences, such as inserted questions or highlighting, has remained without general consensus (Watts and Anderson, 1971; McGaw and Grotelueschen, 1972). Considering the seemingly conflicting roles inserted questions and highlighting seem to exhibit, inspection behavior may or may not be influenced in some of these cases, and therefore may be dependent upon the mode of information, the difficulty of the material and questions, and the relevant learner characteristics. It is very conceivable that inspection behavior alone is an inadequate explanation. Watts and Anderson (1971) have suggested that the review of information a learner performs when answering a question also influences his performance of the acquisition of information. In this study, review in answering inserted text questions has possibly helped in the acquisition of relevant diagram information. However, the review when answering inserted diagram questions did not demonstrate the same effect on acquisition of relevant text information. Here only when highlighting accompanied diagram questions did any facilitation seem to occur. If highlighting is more likely to direct inspection behavior rather than stimulate review, then the benefit of highlighting is perhaps due to a forward shaping of inspection behavior. Specifically, text questions may be credited with causing a review which in turn facilitate the acquisition of diagrammatic information. On the other hand, diagram questions may cause a review but alone they were not found to produce much acquisition of textual information. Therefore, it is probably the highlighting accompanying the diagram questions treatment conditions that influence inspection behavior to include text, thereby facilitating the acquisition of textual information.

Musings concerning the interaction of inspection and review activities can produce many fascinating possibilities, especially when considerations of individual differences become an added component. In this study, the role of associative memory was found to interact with acquisition from textual information. No doubt, learners who formed associations readily were thereby able to review a greater variety of information, and produce a better post-test performance. Likewise, learners who have well developed aptitudes of perceptual speed found inspection activities to be more profitable without the limiting influence of questions or highlighting.

In summary, a word of caution. Direct tests on the cell means of the data have generally failed to reveal any significant differences which can be interpreted as support for shaping inspection behavior. Only through regression analysis where within cell performance variations were inspected were some of the above conjectures possible. Beyond the F test for heterogenity of regression lines, no means was available to determine through some pair-wise comparison whether or not two particular regression lines were in fact significant in their interaction. Therefore, only general trends were discussed unless differences between slopes of the regression lines, as observed through graphing, appeared to be radically different. However, this means to determine "significant" differences is far from producing consistently secure results. Nonetheless, findings reported and summarized here have their greatest value in replication with attention to correcting and improving experimental procedures.

Mathemagenic Behavior: Some Implications For Future Research

The observation that inserted questions facilitate acquisition of incidental information remains without support in this study although inserted questions have been credited with influencing the inspection behavior employed by the learner when learning from written discourse. An alternate explanation suggests that inserted questions stimulate a mental review of the information encoded from the written discourse. Whether or not the involved mathemagenic activity is a review of information learned or a modification of subsequent inspection behaviors, a relationship ought to exist between the variable, inserted questions, and the resulting performance on the incidental post-test questions. The results of this study underscore the necessity to consider other possible variables, in addition to inserted questions, as potential agents to influence mathemagenic activity. The nature of the written material, the complexity of the questions, the incentive of the learner to work with the materials, are only a few of these other contributing variables that may also serve to increase or decrease the acquisition of incidental as well as relevant information from instructional material.

Variables Which May Influence Mathemagenic Activity

Written materials.--Much previous work in mathemagenic activity has utilized Rachael Carson's book, The Sea Around Us. This text contains an abundant array of factual information. Some of the most important educational goals do not entail the type of verbatim recall required by experiments utilizing this written material (Watts and Anderson, 1971). Therefore other materials which approximate school materials must be considered as experimental materials.

One source of experimental material is the myriad of written curriculum material produced by science educators in the last decade and a half. Few of these have ever been tested or evaluated in terms of performance. These materials should be utilized as written materials in mathemagenic studies in order to find clues for more effective implementation or modification of these materials in school settings.

One problem remains concerning the nature of written materials. As discussed in Chapter I (pages 15-16), the balance between the type of content and the quantity of this type of content is a very important variable in written material. Therefore, some suitable schema must be developed that enables the experimenter to identify the complexity, variety, and quantity of the content within the written materials as the taxonomies presently in popular use are simply inadequate (Frase, 1970).

Experimental questions.--If shaping is dependent at all upon reinforcement from the success of answering the experimental question inserted into the written material, then success in answering the question must be taken into consideration. Hence, questions that are difficult and provide only a few learners with the opportunity to answer them should be expected to have little influence upon inspection activity. In this study, questions were relatively difficult with less than 60 percent of the subjects answering the questions correctly. If the questions were less difficult, which could be achieved perhaps by providing multiple choice select items rather than the fill in the blank supply items, their influence upon acquisition could increase.

In addition, type of question has also been limited to the verbatim recall. The extent to which relationships found in the current research may be altered when questions require learners to apply concepts or principles described in a passage should also be empirically determined.

Entering behaviors of learners.--Studies in mathemagenic activities generally assume that the entering behavior of the learner includes processing activities suitable for task presented by the treatment. Studies concerned with performances of learners in school settings should recognize the possibility that some of the participants will not possess suitable skills for processing the materials. Therefore, these studies involve not just the shaping of the entering behavior, but also the more complex task of conditioning a suitable processing activity into the repertoire of the learner.

Another variable among subjects concerns their incentive to attend to presented materials in the instructional setting. Whether an experiment or other regular school activity, passive attention and inattention to presented materials is an important problem. According to the notion of effective stimulus, the role of the learner is tantamount since it is the stimulus encoded by the learner that becomes the basis for subsequent psychological learning activity. Therefore, what is not encoded becomes a very important variable when learner inattention is a characteristic of participation. Perhaps materials with high novelty and visual presentation can help redirect the attention of wandering learners to the instructional material. This level of mathemagenic activity has been generally classified as an orientating and acquisition activity, both subsets of mathemagenic behavior.

Individual differences.--The learning that results from the insertion of questions appears to be a function of several interacting components, such as the variable use of questions, differences in written materials, and the complexity of the questions. Aptitude x treatment interaction studies attempt to link these variables to learner characteristics since it is likely that the effects of such task components on learning from written materials varies for different subgroups of learners.

The aptitude-performance relationships disclosed by this line of research are far from direct classroom application. However, findings do indicate general trends and provide a potential alternative conception for individualized instruction. Here, individualized instruction is based upon providing materials, strategies and environments which permit learners to capitalize on their well developed abilities and yet be compensated for the weaker abilities.

Aptitude x treatment interaction studies are still limited by the "divining rod" measurement of treatment conditions while measuring aptitudes with "micrometers" (Shulman, 1970). However, some long term implications can be outlined. First, there is a great need for instructional materials that help students with developed aptitudes other than the verbal skills. When treatments are found to be positively related to aptitudes other than verbal scores, careful analysis and further testing should be done in order to identify the patterns that may be used to redesign other instructional materials. Second, the evaluation of curriculum materials has too long focused on assessing which material is best. This viewpoint assumes that once found, all learners can perform equally well using the material. Obviously, knowing which material is best on the average provides incomplete information for implementation of the material into the classroom. Of greater importance are findings that report what outcomes learners can be expected to attain using these materials and which learning habits and aptitude characteristics seem to be prerequisites for attaining these outcomes with these materials. Third, observations in classroom settings should be collected which reflect the learning habits and characteristics of learners in school settings across many periods of time. From this data, instructional variables that attenuate learning can be identified and hopefully eliminated while those variables that facilitate learning can become prototypes for redesigning instruction and instructional materials.

Conclusion

This study utilized materials that approximated classroom written materials for science instruction. The findings indicated that inserted adjunct questions were most effective for acquisition of relevant information; no evidence was found to support the influence upon acquisition of incidental information. Time spent in the treatment and individual differences in associative memory were found to be significantly related to performance. These results are generally consistent with other research considering the length of the written passages utilized (Koran, M. L. and Koran, J. J., 1972).

Three types of analytical procedures were utilized in order to answer different questions. Between group differences, trends across written passages, and relationships between a predictor and criterion measure of performance were interpreted as support or no support for research hypotheses. In general, regression analysis was identified to be consistent with problem questions, especially those concerned with variables which may influence mathemagenic activity.

Results of this type of research may not have immediate and practical application to classroom instruction. However, further experimentation may eventually reveal decision rules for modifying instruction and for assigning learners to alternative instructional treatments to teach the same terminal objectives.

APPENDICES

APPENDIX A

DIRECTIONS TO STUDENTS

Student Information Sheet

Please complete the following statements. The information you provide will be important, so please be accurate.

Name: ____________________

Year in School: ____________________

Sex: __________ Age: __________

Date: ____________________

School: ____________________

Teacher: __________ Period: __________

Record the time: ____________________

GO ON TO THE NEXT PAGE

General Directions

It is important that you do your best throughout these materials. The following suggestions will help you.

Each of these booklets has been assembled with some differences. You will notice your neighbor doing something different than you are. You should ignore him.

The materials in this booklet consist of a series of short passages. Each passage contains some *diagrams* and some *written information.*

Study each passage carefully. You will want to remember some of it. At the conclusion of all the passages, you will be asked to answer a set of test items in order to find out how much you remember from each passage.

GO ON TO THE NEXT PAGE.

Directions for Answering Study Items

Please read the following carefully. It contains some important information.

At the conclusion of *each* passage, you will find a *study item* inserted on a separate page. This item will give you a chance to "test yourself" on recalling information.

Once you finish studying the passage and start working on the study item, *DO NOT TURN BACK TO THE PASSAGE*.

Write your answers on the line provided with the study item. If you do not remember the answer, it is alright to guess.

GO ON TO THE NEXT PAGE

Directions for Highlighting

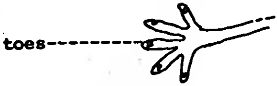
While you are reading this page, hold up your hand and you will receive a yellow felt-point marker.

As you study the following passages, you are to "highlight" or mark with the yellow marker all the information you consider *important and worth remembering* in order to answer the test items.

You may want to highlight a sentence or phrase:

Elephants are mammals.

You may want to highlight a diagram or part of a diagram:



When you receive a highlighter,

GO ON TO THE NEXT PAGE.

Record the time: ______________________________

Directions for Answering Test Items

Answer the following test items as well as you can. If you cannot remember the answer, it is alright to guess. Your score will be based upon how many items you get right with NO penalty for wrong answers.

Write your answers on the line provided with the test item.

DO NOT TURN BACK TO ANY OF THE OTHER MATERIALS IN THIS BOOKLET.

GO ON TO THE NEXT PAGE.

Record the time:______________________________

CLOSE YOUR BOOKLET.

PLEASE WAIT QUIETLY.

When asked, please turn in ALL the materials you were given.

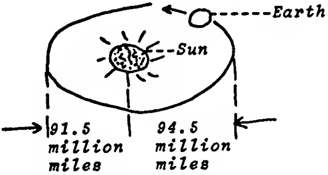
THANK YOU FOR YOUR HELP.

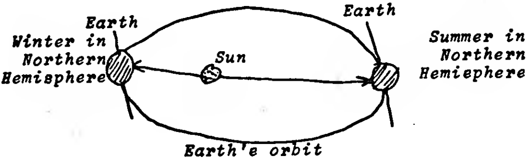
APPENDIX B

READING PASSAGES

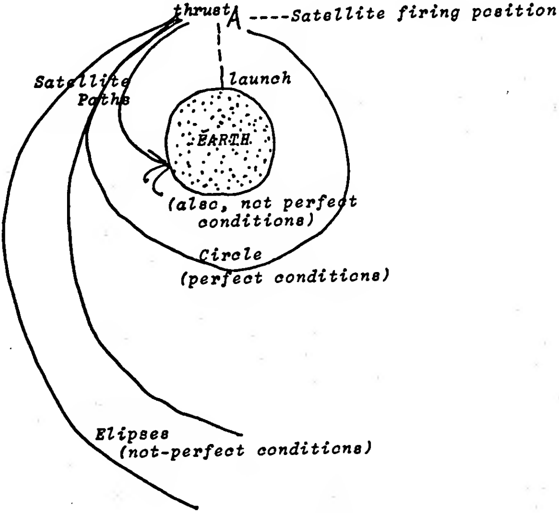
Planet Paths

Kepler, after analyzing masses of numbers giving the positions of the planets over a period of many years, was able to state that for some of the planets the ellipse differed very little from a circle, whereas for others the ellipse is very much off center, or eccentric. For earth, the eccentricity is not very great.





When satellites are launched artificially, they always go into elliptical orbits around the earth, or elliptical orbits around the sun, if they are launched around it. Only a perfect shot could hope to put an artificial satellite into a circular orbit. To achieve a circular shot, the firing speed at a fixed height above the earth would have to be precisely one certain value, and the satellite would have to be fired precisely in a predetermined direction, parallel to the plane of the earth's horizon below.


thrust
A ----Satellite firing position
Satellite Paths
launch
EARTH
(also, not perfect conditions)
Circle (perfect conditions)
Elipses (not-perfect conditions)

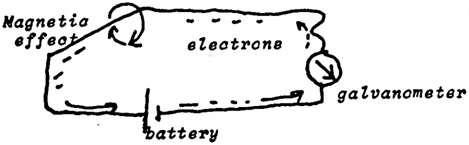
Suppose we were to put an artificial satellite into a circular orbit. Now, suppose we were to try a second time for a circular orbit. If the launching speed were greater than that at A, we would get an ellipse - not a circle. Or, if the direction differed slightly, we would get an ellipse.

DO NOT TURN BACK TO THE READING PASSAGE

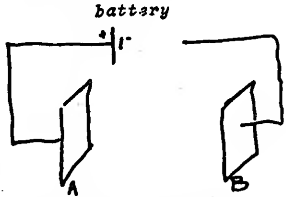
GO ON TO THE NEXT PAGE

Electric Effect

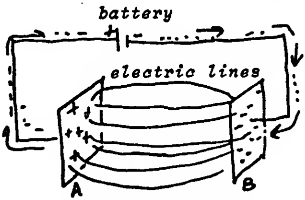
Current is presumably a current of electrical particles, and we call it a "conduction current." Today we believe that the flow is in the direction of negative to positive and that it consists of electrons, or tiny negative charges.



Maxwell, however, felt that there was more to this. He had a hunch that we ought to get a magnetic field not only when charged particles were flowing, as in a wire, but even when they did not actually flow through a space. Here is what we mean:



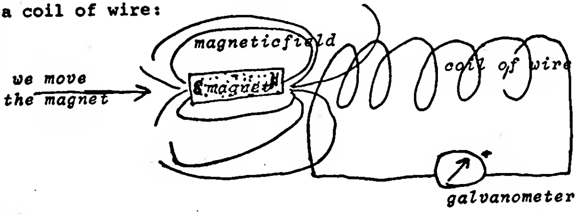
uncharged metal plates



charged metal plates

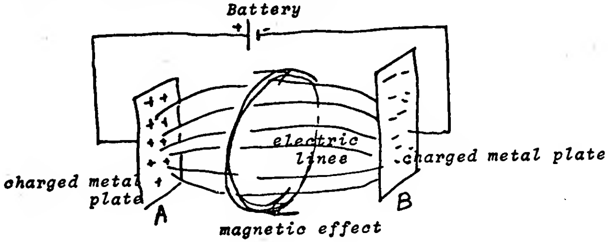
As the charges begin to appear on the plates, electric lines begin to reach across from say, plate A to plate B. Maxwell called the electric lines pulsing through space a "displacement current."

Now, as the lines increase in number, because of the charging up of the plates, we have electric lines pulsing through space. In Faraday's discovery, we have magnetic lines pulsing through space - through the space enclosed by a coil of wire:



And what happened? An electrical flow began to occur. As a matter of fact, the coil is not absolutely necessary. If magnetic lines simply pulse through any space, an electrical effect is created around the magnetic pulse.

Maxwell reasoned that when electric lines pulse through a space - such as that between the two metallic plates or any space at all - a magnetic effect should come into existence around the pulsing electric lines.

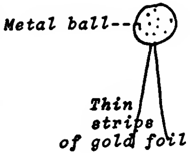


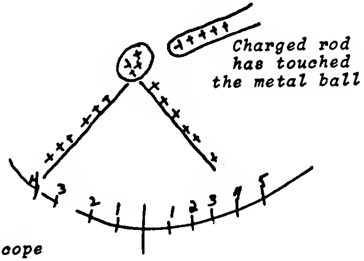
DO NOT TURN BACK TO THE READING PASSAGE

GO ON TO THE NEXT PAGE

Testing Radioactivity

How can we tell whether a substance gives out rays, that is, whether it is radioactive?

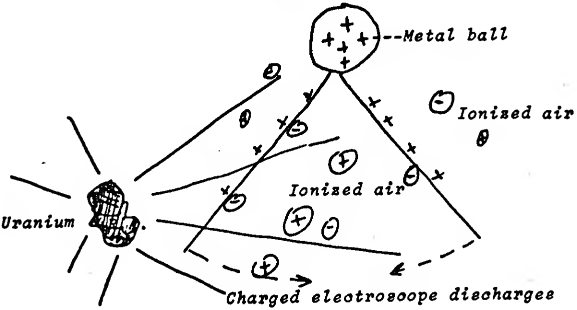




An Elsotroscope

The gold strips, you see, take on the charge, let's say a plus charge. As you know, like charges repel each other. Thus, the strips move away.

Now, let us bring some uranium close to the electroscope. The rays from the uranium break up many atoms of the air surrounding the electroscope. Negative charges from these atoms drift toward the positively charged foils. Gradually, the gold strips are neutralized. Accordingly, the foils repel each other with less force. Responding to gravity, they move in toward each other.



Thus, from the rate of the collapse of the gold strips, we can learn how strong the uranium sample is. By just such a method, Marie learned that thorium, too, emits rays.

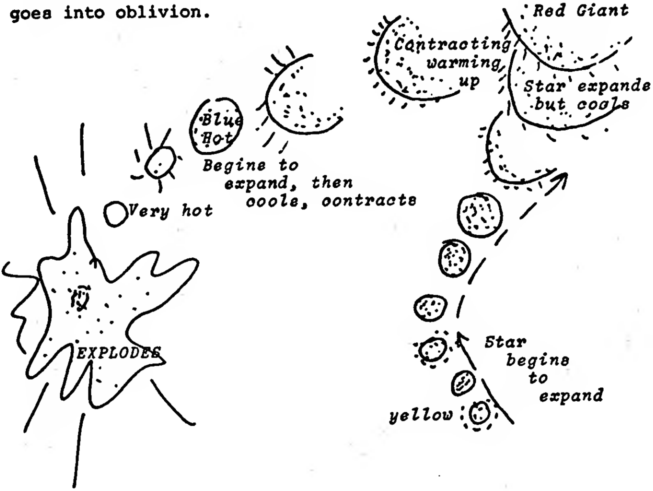
In 1898, after a long examination of various ores, Marie discovered a new substance which emitted rays, a new element, which she named "polonium" in honor of her native land.

DO NOT TURN BACK TO THE READING PASSAGE

GO ON TO THE NEXT PAGE

Star Stability

And what exactly happens in general to a star that begins to lose its stability? The star heats up, expands enormously, and then cools because of expansion. After this point of development has been reached, the star may begin to swell and contract alternately. On the other hand, the star may go on contracting rapidly and cause such heating up that violent nuclear reactions take place, and it explodes, blowing itself to smithereens. Only a small part of this star remains, a cool "white Dwarf" that fades from view and goes into oblivion.



Will our sun behave in this way? It is expected that the sun will go through this routine in about eight billion years. As you can see, we have plenty of time in which to pack our suitcases and prepare to leave for the planet of another star.

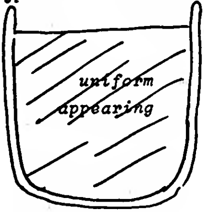
DO NOT TURN BACK TO THE READING PASSAGE

GO ON TO THE NEXT PAGE

Water

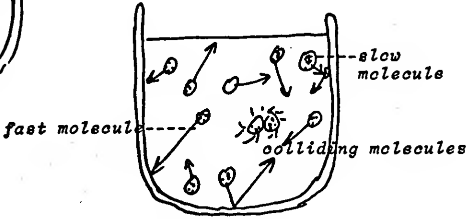
Lukewarm water is not at all a static substance. Its average effect, yes, is that of a lukewarm condition. But in reality, it consists of fast molecules, slow molecules, and molecules having near-average speeds. All these molecules are in constant motion, colliding with each other and with the walls of the container, gaining speeds, losing speeds, exchanging speeds.

Typical "over-all" view



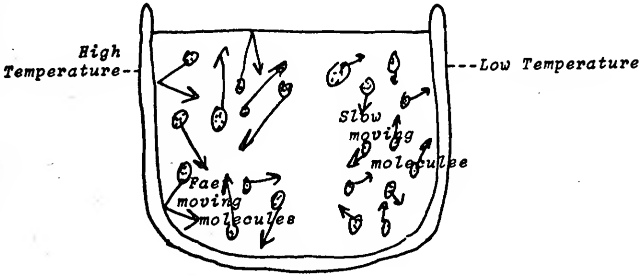
Lukewarm Water

Molecular view



Lukewarm Water

So what? So it means that a chance exists that by random motions, some day, a significant fraction of all the fast molecules will gather at the left, and a large number of slow ones will gather at the right. Then what? Then the left side of the bucket will be hot and the right side will be cold. The water in the bucket is no longer lukewarm.



And in that case, we are back where we started, essentially: the hot side can begin to mix with the cold side, and the world of the bucket is at the beginning of time. Mixing is about to begin.

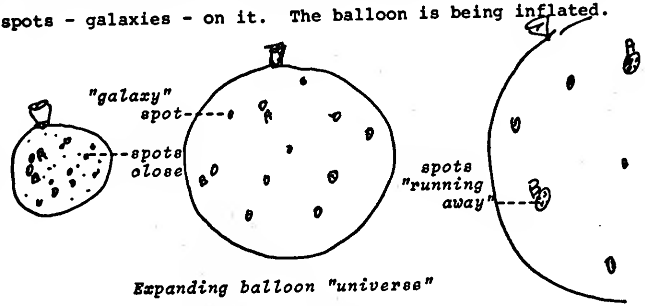
DO NOT TURN BACK TO THE READING PASSAGE

GO ON TO THE NEXT PAGE

Galaxies

Hubble, with other astronomers, found an amazing thing: the galaxies are running away from each other!

They seem to be running away from us. Yet, it is easy to understand that an astronomer on another galaxy would say, "They are running away from us." Can everyone say such a thing, no matter on which galaxy? Yes. How about thinking of it all this way: We have a balloon with spots - galaxies - on it. The balloon is being inflated.



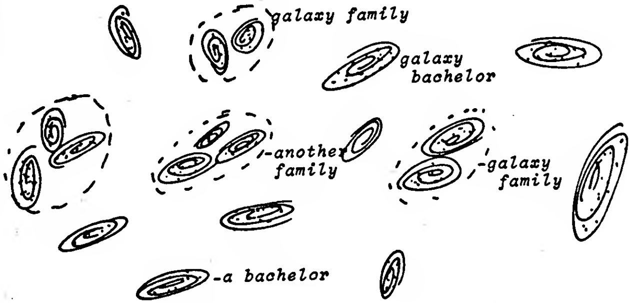
Expanding balloon "universe"

If we stand at A, as the balloon inflates, every "galaxy" will be running away from us. Yet, when we stand at B, we'll say the same thing. Every galaxy still runs away.

The universe is expanding, astronomers concluded. What a remarkable conclusion.

There was a theory about a universe that could be expanding, and here Hubble was bringing in the observational facts.

Before I forget, I want to say that not every galaxy runs away from each other. Here is what I mean:



Whole families of galaxies run away from each other. But members of an individual family usually approach each other, because of mutual gravitational attraction.

We still, then, have an expanding universe.

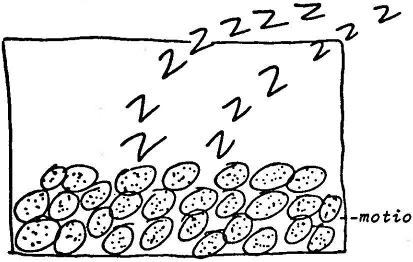
Incidentally, some of the galaxies have collided. They were probably members of a family who met for a reunion.

DO NOT TURN BACK TO THE READING PASSAGE

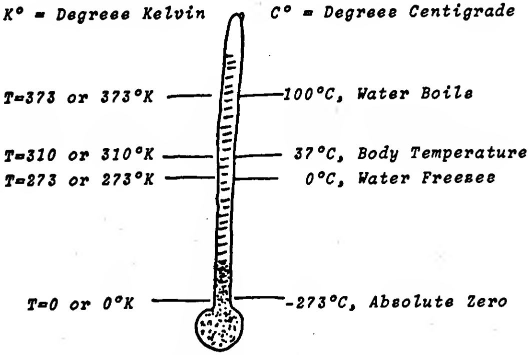
GO ON TO THE NEXT PAGE

Temperature

William Thomson, or Lord Kelvin, accomplished a great deal more than inventing the refrigerator. He calculated that there must be a lowest temperature in the universe. At such a temperature, the atoms would stop moving completely, and go to sleep. This temperature he called absolute zero.



Would it make any sense to speak of lower temperatures? No, not if we go along with the atomic notions. Not if we accept the theories concerning moving particles and how their speeds correspond to temperature. We like to speak of temperature as beginning at Kelvin's Absolute Zero. Doesn't that make good sense? So we have a Kelvin Scale.



$K^\circ = C^\circ + 273$

Lord Kelvin worked out his absolute scale and the absolute zero through the ideas of heat flowing toward cold. We can think of a machine that has energy given to it - let's say in the form of heat. The machine works. Perhaps it pushes something. Then there is the exhaust heat. If only the exhaust could be at absolute zero! Boy, would we have an efficient machine!

To get an exhaust of absolute zero, we would have to squeeze everything out of the working fuel. We would have to extract all of the energy. All that would be left would be an absolutely blah exhaust. A really exhausted exhaust.

DO NOT TURN BACK TO THE READING PASSAGE

GO ON TO THE NEXT PAGE

APPENDIX C

INSERTED TEXT QUESTIONS

COMPLETE THE FOLLOWING SENTENCE:

If the launching speed is greater than a certain value, the satellite orbit that results will be

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

When current is a current of electrical particles, it is called a

____

current.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

Stars explode when they heat up because of violent ______________________________ that take place.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

The electroscope foils move toward each other when discharged in response to

____

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

The chance exists that a significant fraction of fast molecules could gather in one spot through

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

Hubbel presented ______________________________

facts to support the expanding universe theory.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE:

According to Kelvin, speeds of moving molecules correspond to

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

APPENDIX D

INSERTED DIAGRAM QUESTIONS

COMPLETE THE FOLLOWING SENTENCE.

The furthest away the earth gets from the sun is

____

miles.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

In Faraday's experiment, a

____

was used to measure current flow.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

An electroscope is made up of a metal ball and

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

A contracting star becomes

____

hot.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

From the typical view point, lukewarm water appears to be

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

According to the article about galaxies, a single galaxy is called

____.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

COMPLETE THE FOLLOWING SENTENCE.

Water freezes at

____

°Kelvin.

GO ON TO THE NEXT PAGE. DO NOT TURN BACK TO THIS PAGE EVEN IF YOU COULD NOT COMPLETE THE ABOVE SENTENCE.

APPENDIX E

POST-TEST

*In Faraday's experiment, a

____

was used to measure current flow.

*In the article describing the testing of radioactive materials, the electroscope was charged

____.

*According to the article about galaxies, a single galaxy is called

____.

*The furthest away the earth gets from the sun is

____

miles.

*Absolute zero is equal to

____°

Centigrade.

*Our sun will go through the star cycle in about

____

years.

*The chance exists that a significant fraction of fast molecules could gather in one spot through

____.

<ins>GO ON TO THE NEXT PAGE</ins>.

*Maxwell charged his electrical plates by attaching them to a

____.

*Efficient machines extract all of the

____

from the working fuel.

*Stars explode when they heat up because of violent

____

that take place.

*"An ellipse very much off center" describes

____

orbit.

*Using an electroscope, Marie Curie learned that

____

was radioactive.

*From the typical viewpoint, lukewarm water appears to be

____.

*Hubbel presented

____

facts to support the expanding universe theory.

GO ON TO THE NEXT PAGE.

*If the launching speed is greater than a certain value, the satellite orbit that results will be

______________________________.

*According to the article about galaxies, two or more galaxies that move together are called

______________________________.

The electroscope foils move toward each other when discharged in response to

______________________________.

*A contracting star becomes

____

hot.

*An electrical effect is created around

____

pulsing through any space.

*According to Kelvin, speeds of moving molecules correspond to

______________________________.

*Fast moving molecules produce a high

______________________________.

GO ON TO THE NEXT PAGE.

*An electroscope is made up of a metal ball and

____________________________________.

*Winter in the northern hemisphere occurs when the earth is

____

the sun.

*Expanding stars become

____

giants.

*Lukewarm water is not a

____

substance.

*Water freezes at

____________________________________°

Kelvin.

*Members of an individual galaxy family approach each other

because of ______________________________.

*When a current is a current of electrical particles, it is

called a ______________________________

current.

GO ON TO THE NEXT PAGE

APPENDIX F

DATA SUMMARY FORM

Identification number:______________________

Name:________________School:________Teacher:_____Period___

Year in School:_______Age:______Sex:_______Date:___________

Time Measure:
Time start:______________
Middle:______________ Reading time:______________

Finished:______________ Test time:________________

Treatment (check):

___Diagram Questions ___Highlighting
___Text Questions ___No Highlighting
___No Questions

Inserted Questions: (1 = correct, 0 = incorrect)

1.__2.__3.__4.__5.__6.__7.__ Total correct:_______

Post Test Questions (R=relevant, I=incidental, V=very incidental)

Diagram A: ___________ Text A: ______________

Diagram B: ___________ Text B: ______________

Diagram Total ___________ Text Total ______________

Grand Total________________

Aptitude Measures:

Vocabulary (V-2):______, ______, ______

Number-Comparison Test (P-2):______

Hidden Figures (patterns) (CF-2):______

Auditory Letter Span Test (Ma-3):______

Object-Number Test (Ma-2):______

__________________: ______, ______, ______

__________________: ______, ______, ______

__________________: ______, ______, ______

Post Test Questions - Score Sheet

No.	Ident. Quote:	D(A)	D(B)	T(A)	T(B)
1.	In Faraday's	___			
2.	Elect. Charged		___		
3.	Single galaxy	___			
4.	Furthest away	___			
5.	Absolute zero		___		
6.	Our sun will				___
7.	Chance exists			___	
8.	Maxwell charged		___		
9.	Efficient machines				___
10.	Stars Explode			___	
11.	Elipse off center				___
12.	Using electroscope				___
13.	Typical viewpoint	___			
14.	Hubbel presented			___	
15.	Launching speed			___	
16.	Two galaxies		___		
17.	Electroscope foils			___	
18.	Contracting star	___			
19.	Electrical effect				___
20.	According to Kelvin			___	
21.	Fast Molecules		___		
22.	Electroscope made up	___			
23.	Winter in north		___		
24.	Expanding stars		___		
25.	Lukewarm water				___
26.	Water freezes at	___			
27.	Members of family				___
28.	Current is a current			___	
	TOTALS:	___	___	___	___

Highlighting Score Sheet

Title:	Source:	Information highlighted:	Total	(%)
Planet Paths:	D:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18		
	T:	1 2 3 4 5 6 7 8 9 10 11		
Electric Effect:	D:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20		
	T:	1 2 3 4 5 6 7 8 9 10 11 12 13 14		
Testing Radioactivity:	D:	1 2 3 4 5 6 7 8 9 10 11 12		
	T:	1 2 3 4 5 6 7 8 9 10 11 12 13		
Star Stability:	D:	1 2 3 4 5 6 7 8 9 10		
	T:	1 2 3 4 5 6 7 8		
Water:	D:	1 2 3 4 5 6 7 8 9 10 11 12		
	T:	1 2 3 4 5 6 7 8 9 10 11 12		
Galaxies:	D:	1 2 3 4 5 6 7 8 9 10 11 12 13		
	T:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17		
Temperature:	D:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15		
	T:	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19		

Totals (%) D = ________ T = ________

APPENDIX G

DISTRIBUTIONS OF SCORES

The following symbols were used to represent treatment conditions in the tables of distributions of dependent and independent measures.

Symbol:	Treatment condition:
DQ/H	Inserted Diagram Questions with highlighting
TQ/H	Inserted Text Questions with highlighting
NQ/H	No inserted questions with highlighting
DQ/NH	Inserted Diagram Questions without highlighting
TQ/NH	Inserted Text Questions without highlighting
NQ/NH	No inserted questions without highlighting

DISTRIBUTION OF SCORES FOR VOCABULARY, PART 1

	Frequency by treatment condition						Total Frequency
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	
0							
1	1					2	3
2			2	1			3
3	1		2		2	2	7
4		1	1		1		3
5	4	2	4	2	5	2	19
6	1	1	2	5		1	10
7	4	4	3	8	3	4	26
8	3	7	6	2	2	8	28
9	5	4	1	1	2	2	15
10	2	3	4	6	2	3	20
11	5	1	3	3	1	2	15
12	1	1		1	7	3	13
13	2	4	2		1	1	10
14	1				1		2
15			2	1	1		4
16		1		1		2	4
17				1		1	2
18							

DISTRIBUTION OF SCORES FOR VOCABULARY, PART 2

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0							
1							
2	1						1
3	2		1	1	1	1	6
4	1	1	3	3	1	1	10
5		1	2	3	4	6	16
6	4	6	1	5	2	1	19
7	4	2	5	3	2	3	19
8	3	3	2	2	4	2	16
9	4	4	6	2	2	5	23
10	1	3	3	4	2	4	17
11	2	2	2	3	5		14
12	1	4	1	2	2	3	13
13	3	1	3	1	1	2	11
14	2	1	1	2	2	2	10
15	1	1	1	1		2	6
16			1		1	1	3
17		1					1
18							

DISTRIBUTION OF SCORES FOR VOCABULARY TOTAL

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
5	1						1
6			1		1	2	4
7			2	1			3
8	1				1		2
9	1				1	1	3
10	2	1	2	2	1	2	10
11	1	2	1	2	3	2	11
12	1	2	3	4	1	3	14
13	1	2	1	5	1		10
14	3	1			1	2	7
15	1	2	3	1	3	1	11
16	4	2	4	3	1	1	15
17	1	2	1	1	1	5	11
18	1	3	2			1	7
19		3	3	2	2	1	11
20	2	2		2	1		7
21	2		2	3	1	1	9
22	1	2	1	1	1	1	7
23	1		2	1	2	2	8
24	1	2			3	2	8
25		1					1
26	2	1	1	1	3	2	10
27	1	1				1	3
28	1						1
29			1	2		1	4
30		1					1
31		1	1				2
32				1	1	2	4

NUMBER COMPARISON, PART I

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	2	2	1	2		2	9
1							
2							
3						1	1
4	1		1			1	3
5			1		2		3
6	2					1	3
7					1	1	2
8	2	2	5	2	4	2	17
9	3	1	3	3	2	2	14
10	5	3	2	8	6	3	27
11	4	8	2	7	5	7	33
12	4	6	3	1	2	5	21
13	2	3	7	5	1	2	20
14	2	2	3	1	2	2	12
15	1	1	1	1	2	1	7
16	1	1	2	1		1	6
17				1	2	1	4
18							
19			1				1
20						1	1
21							
22							
23		1					1

DISTRIBUTION OF SCORES FOR HIDDEN PATTERNS, PART 1

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
1- 2							0
3- 4		1			1	1	3
5- 6		1					1
7- 8							0
9-10	1	1	2	1	1	1	7
11-12	2		2	1	1		6
13-14				2	2	2	6
15-16	2	1	1	1		2	7
17-18	3	1	1	2	1	1	9
19-20	2	3	1	4	1	2	13
21-22	2	2	1	2	2		9
23-24	3		1	1		3	8
25-26		2	3	2	2	3	12
27-28	4	1	1	2		3	11
29-30	1	2	2	3	2	2	12
31-32	1	4	2	3	8	4	22
33-34	3	6	2	2	5	2	21
35-36	2		2	3		1	8
37-38		1	2	3		1	7
39-40			5		1		6
41-42	2	1	3		1	1	8
43-44		1	1			3	5
45-46					1		1
47-48	1						1
49-50		1				1	2

DISTRIBUTION OF SCORES FOR AUDITORY LETTER SPAN

	Frequency by treatment condition						Total Frequency
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	
0					1		1
1					1		1
2		2	1	1		1	5
3	6	2	3	1	4	1	17
4	3	4	5	5	2	4	23
5	3	6	2	9	7	7	34
6	7	9	9	8	7	7	47
7	6	4	6	5	1	6	28
8	1	2	4	2	4	3	16
9	1		1			3	5
10	2			1	1		4
11		1	1		1		3

OBJECT NUMBER, PART 1

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	1				2		3
1	2	1	2	3	2	4	14
2	5	4	3	6	4	2	24
3	4	8		5	1	2	20
4	1	2	4	3	1	5	16
5	1	3	4	4	4	2	18
6		4	6	3	1	2	26
7	4	4	5		3	4	20
8	3	1	5	2	5	2	18
9	2		1	2	1	4	10
10	1	1			1	1	4
11					1	1	2
12	3				1		4
13	1	1	1	2	2		7
14	1		1	1		1	4
15		1		1		2	4

INSERTED QUESTIONS

	Frequency by treatment condition						Total Frequency
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	
0	3	2		1	1		7
1	2	8		6	3		19
2	3	4		6	5		18
3	11	6		2	8		27
4	6	7		12	6		31
5	2	2		5	5		14
6	2	1			1		4
7							

TREATMENT TIME

	Frequency by treatment condition						Total Frequency
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	
44-45		1					1
42-43							
40-41	1						1
38-39	1				1		2
36-37		1					1
34-35	2	3		1		1	8
32-33	3	1	1	2	1		8
30-31	1	1	1	1		1	5
28-29	6	3	1	2	2		14
26-27		5	1	1	1		8
24-25	5	4	2	3	4	2	20
22-23	3	2	5	2	2	2	16
20-21	2	3	6	4	4		19
18-19	2	3	2	5	3	4	19
16-17		3	9	4	4	5	25
14-15	3		2	3	2	6	16
12-13			2	4	3	4	13
10-11					2	3	5
8- 9						3	3
6- 7							
4- 5						2	2

TEST TIME

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
3			1				1
4							
5	4	3		2	1	1	11
6	4	4	1		1	1	11
7	4	4	3	2		3	16
8	4	5	3	3	6		21
9	1	3	3	9	6	3	25
10	6	6	7	6	7	4	36
11	1	1	3	3	1	1	10
12	3	1	4	3	1	2	14
13			1		1	4	6
14	1		2		2	3	8
15			2	2		5	9
16					2		2
17	1	1	1			2	5
18						1	1
19						1	1
20					1	1	2
21							
22						1	1
23							
24							
25				2			2
--							
39		1					1
40							
41		1					1

RELEVANT DIAGRAM QUESTIONS

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	4	7	9	2	3	5	30
1	3	11	7	5	4	9	39
2	8	7	10	7	11	6	49
3	6	2	3	7	7	5	30
4	4	2	3	7	3	3	22
5	2	1		4	1	4	12
6	2					1	3
7							

INCIDENTAL DIAGRAM QUESTIONS

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	2	2	2	1	2	2	11
1	5	5	5	3	1	6	25
2	2	3	3	8	2	5	27
3	10	10	12	2	9	5	58
4	6	3	4	8	9	9	39
5	2	1	4	8	3	3	21
6	2	3		2	3	2	9
7		1	1			1	3

RELEVANT TEXT QUESTIONS

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	8	4	5	14	3	8	42
1	5	8	8	6	4	16	47
2	9	6	11	8	7	6	47
3	3	6	5	1	10	2	27
4	1	4	2	2	2		11
5	2	1	1	1		1	6
6		1	1		3		4

INCIDENTAL TEXT QUESTIONS

	Frequency by treatment condition						Total Frequency
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	
0	4	5	3	1	4	4	21
1	5	6	6	17	7	10	51
2	6	7	7		3	7	30
3	9	8	6	6	7	3	39
4	5	2	3	4	4	7	25
5		2	6	2	4	1	15
6			1	1			2
7				1		1	2

OVER-ALL POST-TEST PERFORMANCE

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0	1	1					2
1		1			1	2	4
2	1	1	2	1		3	8
3	2		3		1	1	7
4	1	4	2	5		2	14
5	2	3	3	1	2	3	14
6	2	1		4	1	3	11
7	2	3	3	1	3	1	13
8		2	5	6	1	1	15
9	4	4	3	2	1	5	20
10	1		1		2		4
11	5	2	1		4	2	14
12	2	2	1	1	3		9
13	1		5		3	2	12
14	1	1	1	5	3	3	14
15	1	1		2		2	6
16		1			2		3
17	2	2		2			6
18		1	1	1		3	6
19					1		1

PERCENT OF INFORMATION HIGHLIGHTED IN DIAGRAMS

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0- 1	10	14	9				33
2- 3	2	1	5				8
4- 5	5	3	1				9
6- 7	1	1					2
8- 9	2	1	1				4
10-11		3	3				6
12-13			3				3
14-15		1					1
16-17		2					2
18-19	1		3				4
20-21			1				1
22-23		1					1
24-25			1				1
26-27							
28-29		1	1				2
30-31		1					1
32-33			1				1
34-35			1				1
36-37	1		1				2
38-39	1						1
40-41	1						1
42-43							
44-45	1						1
46-47							
48-49	1	1					2
50-51	1						1
52-53							
69	1						1
81	1						1

PERCENT OF INFORMATION HIGHLIGHTED IN TEXT

	Frequency by treatment condition						Total
Scores:	DQ/H	TQ/H	NQ/H	DQ/NH	TQ/NH	NQ/NH	Frequency
0- 3		2					2
4- 7	2	1					3
8-11	3						3
12-15		3					3
16-19	3		1				4
20-23	2	1	2				5
24-27	2	1	4				7
28-31	1	1	3				5
32-35	2	3	1				6
36-39	1	2	2				5
40-43	3	2	3				8
44-47	1	2	5				8
48-51	1	2	1				4
52-55	2	1	2				5
56-59	1	3	5				8
60-63	1	1	2				4
64-65	3		1				4
70-		1					1
77-		2					2
84-		1					1
89-91	1	1					2

BIBLIOGRAPHY

Anderson, R. C. Control of student mediating process during verbal learning and instruction. Review of Educational Research, 1970, 40, 349-369.

Ausubel, D. P. Educational Psychology: A Cognitive View. New York: Holt, Rinehart and Winston, 1968.

Ausubel, D. P. and Fitzgerald, D. Organizer, general background, and antecedent learning variables in sequential verbal learning. Journal of Educational Psychology, 1962, 53, 243-249.

Berliner, D. and Cahen, L. Trait-treatment interactions and learning. In Review of Research in Education, F. E. Peacock Inc. In press, 1973.

Bruning, R. H. Effects of review and test-like events within the learning of prose material. Journal of Educational Psychology, 1968, 59, 16-19.

Cronbach, L. J. Essentials of Psychological Testing. 3rd ed. New York: Harper and Row, 1970.

__________. The two disciplines of scientific psychology. American Psychologist, 1957, 12, 671-684.

__________. Individual differences in learning ability as a function of instructional variables. Basic and Applied Research Proposal, Submitted to the U.S. Commission of Education, August, 1965.

Cronbach, L. J. and Snow, R. E. Individual differences in learning ability as a function of instructional variables. Final report, 1969, U.S.O.E., Contract No. OEC-4-6-061269-1217, School of Education, Stanford University.

Draper, N. R. and Smith, H. Applied Regression Analysis. New York: John Wiley and Sons, 1966.

Frase, L. T. Learning from prose material: length of passage, knowledge of results, and position of questions. Journal of Educational Psychology, 1967. 58, 266-272.

__________. Some data concerning the mathemagenic hypothesis. *American Educational Research Journal*, 1968, *5*, 181-189. (a)

__________. Effect of question location, pacing, and mode upon retention of prose materials. *Journal of Educational Psychology*, 1968, *59*, 244-249. (b)

__________. Some unpredicted effects of different questions upon learning from connected discourse. *Journal of Educational Psychology*, 1968, *59*, 197-201. (c)

__________. Cybernetic control of memory while reading connected discourse. *Journal of Educational Psychology*, 1969, *60*, 49-55.

__________. Boundary conditions for mathemagenic behaviors. *Review of Educational Research*, 1970, *40*, 337-347.

French, J. W., Ekstrom, R. B., and Price, L. A. *Kit of Reference Tests for Cognitive Factors*. Princeton: Educational Testing Service, 1963.

Gagne, R. M. and Paradise, N. E. Abilities and learning sets in knowledge acquisition. *Psychological Monograph*, 1961, *75*, No. 14 (Whole No. 518).

Glaser, R. Individuals and learning: the new aptitudes. *Educational Researcher*, 1972, *1*, 5-13.

Hall, R. V., Lund, D. and Jackson, K. Effects of teacher attention on study behavior. *Journal of Applied Behavior Analysis*, 1968, *1*, 1-12.

Hershberger, W. A. Self evaluational respond and topographical cuing: techniques for programming self-instructional materials. *Journal of Educational Psychology*, 1964, *55*, 288-369.

Keislar, E. R. A descriptive approach to classroom motivation. *Journal of Teaching Education*, 1960, *11*, 310-315.

Kirlinger, F. N. *Foundations of Behavioral Research*. New York: Holt, Rinehart, and Winston, 1964.

Koran, M. L. Aptitude, achievement, and the study of aptitude-treatment interactions. A paper presented at the CTB/McGraw-Hill Invitational Conference, Carmel, California, February, 1973.

Koran, M. L. and Koran, J. J. Differential response to question pacing in learning from prose. A paper presented at the annual American Educational Research Association, Chicago, 1972.

Koran, M. L., Snow, R. E., and McDonald, F. J. Teacher aptitude and observational learning of a teaching skill. Journal of Educational Psychology, 1971, 62, 219-228.

Koran, J. J. and Koran, M. L. Differential response to structure of advance organizers in science instruction. Journal of Research in Science Teaching. In press, 1973.

McGaw, B. and Grotelueschen, A. Direction of the effect of questions in prose material. Journal of Educational Psychology, 1972, 63, 580-588.

Melton, A. Individual differences and theoretical process variables: general comments on the conference. In R. Gagne (Ed.), Learning and Individual Differences. Columbus, Ohio: Charles E. Merrill, 1967.

Plenderleith, M. and Postman, L. Individual differences in intentional and incidental learning. British Journal of Psychology, 1957, 48, 421-428.

Posin, D. Q. Dr. Posin's Giants. Evanston, Illinois: Row, Peterson, 1961.

Postman, L. and Sanders, V. L. Incidental learning and the generality of set. Journal of Experimental Psychology, 1946, 36, 153-165.

Rothkopf, E. Z. Some conjectures about inspection behavior in learning from written sentences and the response mode problem in programmed self instruction. Journal of Programmed Instruction, 1963, 2, 31-46.

____________. Some theoretical and experimental approaches to problems in written instruction. In J. D. Krumboltz (Ed.), Learning and the Educational Process. Chicago: McNally, 1965, 193-221.

____________. Learning from written materials: an exploration of the control of inspection behavior by test-like events. American Educational Research Journal, 1966, 3, 241-249.

____________. Two scientific approaches to the management of instruction. In R. M. Gagne and W. J. Gephart (Eds.), Learning Research and School Subjects. Itasca, Ill.: F. E. Peacock, 1968, pp. 107-133.

____________. The concept of mathemagenic activities. Review of Educational Research, 1970, 40, 325-336.

Rothkopf, E. Z. and Bisbicos, Ethel. Selective facilitative effects of interspersed questions on learning from written material. Journal of Educational Psychology, 1967, 58, 56-61.

Rothkopf, E. Z. and Coke, Esther U. Variations in phrasing, repetition interval, and the recall of sentence material. Journal of Verbal Learning and Verbal Behavior, 1966, 5, 86-91.

Salamon, G. and Suppes, J. Learning to generate subjective uncertainty: the effects of training, verbal ability, and stimulus structure. Journal of Personality and Social Psychology. In press, 1973.

Shulman, L. S. Reconstruction of educational research. Review of Educational Research, 1970, 40, 371-396.

Tenenberg, M. S. Effects of different study instructions on learning from written materials. Doctoral dissertation, University of California, Berkeley, 1969.

Thurstone, L. L. A factor analysis study of perception. Psychometric Monographs, 1944, No. 4.

Walker, H. M. and Buckley, N. K. The use of positive reinforcement in conditioning attending behavior. Journal of Applied Behavior Analysis, 1968, 1, 245-250.

Watts, G. H. and Anderson, R. C. Effects of three types of inserted questions on learning from prose. Journal of Educational Psychology, 1971, 62, 387-394.

Winer, B. J. Statistical Principles in Experimental Design. 2nd ed. New York: McGraw-Hill, 1971.

Woodworth, R. S. Experimental Psychology. New York: Holt, 1938.

BIOGRAPHICAL SKETCH

Born on June 28, 1937, in Palo Alto, California, John Thurlow Wilson lived with his parents, Norman and Sarah Wilson and two sisters, Judy and Patty. He received his early education in San Jose and Campbell School districts. Upon graduation from high school, he went to the University of Northern Colorado, Greeley, Colorado.

At Greeley, his major was physical science with emphasis in chemistry, and a minor in mathematics. His work in Greeley included a laboratory assistantship with Miss Edith M. Selberg. This relationship has continued through the present. Her interest in his abilities encouraged him to pursue both a masters and a doctorate. His masters, also earned at Greeley, was in physical science and science education.

While his experience includes ten year of teaching in public school, the ages taught encompass children in kindergarten through adults in college. His college teaching experience includes teaching at San Jose State, and the University of Hawaii, where both he and his wife trained Peace Corps volunteers for service in Tonga.

His doctorate education began in the University of Texas at Austin, where he met Dr. John J. Koran. When Dr. Koran moved to Gainesville, Florida, the opportunity was available to move also.

John Thurlow Wilson is not a newcomer to the field of science education. He has been active in NSTA for over ten years and has delivered more than eight papers to meetings of various science associated professional organizations, in addition to six publications (not including the dissertation) in professional journals, and many miscellaneous technical reports and monographs. His research activities have included microteaching and teacher behaviors, hunch generation in inquiry activity, discipline and classroom mangement of misbehavior, mathemagenic activity, and individual differences in performance-instructional treatment relationships.

He is currently a life member of the National Science Teachers Association, and a member of National Association of Research in Science Teaching, American Educational Research Association, and Phi Delta Kappa.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John J. Koran, Jr., Chairman
Associate Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

John F. Baxter

John F. Baxter
Professor of Chemistry

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Wilson H. Guertin
Professor of Education
Professor of Psychology

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Arthur J. Lewis

Arthur J. Lewis
Professor of Education

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Mary Budd Rowe

Mary Budd Rowe
Associate Professor of Education

This dissertation was submitted to the Dean of the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

June, 1973

B. L. Sharp by MC Baker

Dean, College of Education

Harry H. Sisler

Dean, Graduate School